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Feature Article

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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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Feature Article

Best Practices and Lessons Learned in Grant Writing for Ag/Applied Economists to Engage in Interdisciplinary Studies

Chyi-Lyi Liang[a], Siân Mooney[b], Lyubov Kurkalova[a], D. Keith Roper[c], and Leila Hashemi-Beni[a]

North Carolina Agricultural and Technical State University[a], Indiana University - Bloomington and IUPUI[b], Utah State University[c]

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Abstract

Learning to write successful grant applications takes significant time and effort. This paper presents knowledge, expertise, and strategies from experienced grant applicants and grant officers across several disciplines to support early career scholars and first-time grant writers, with particular guidance for interdisciplinary collaboration. Many Agricultural and Applied Economists are invited to participate in interdisciplinary grant applications. It is important to fully understand the types of projects, nature of collaboration, co-investigators' characteristics, expected contributions, anticipated benefits, and valuation of collaborative research by one's peers before initiating new opportunities. Leading and participating in interdisciplinary teams also requires mentorship, patience, professionalism, and excellent communication beyond the scientific merits. This paper shares practical insights to guide scholars through the grant-writing processes beginning with nurturing a mindset, preparing for a consistent work ethic, actively seeking advice, identifying targeted programs, matching a programs' priorities, a step-by-step framework for team creation and management, effectively managing time and pressure, and transforming failure into success.

1 Introduction

Seeking funding is a common expectation for employees in academia, nonprofit, and private enterprises focused on research, teaching, and outreach activities. Successful grant applications often lead to favorable evaluations for productivity, tenure, promotion, and other career advancements. Quantitative evaluation of historical trends and success rates of different individuals from a range of disciplines that apply for various grants is limited. Some scholars have discussed grant-writing mistakes and suggested remedies (e.g., Mikal and Rumore 2018; Sohn 2020), and some institutions offer grant-writing workshops, with particular focus on early-career researchers. In general, scholars working in academia are most likely to participate in grant writing to advance scientific knowledge and application that will continuously stimulate rigorous research, innovative teaching, and dynamic outreach (Keogh 2013; Lovitts 2008). There is emerging interest to build multidisciplinary and interdisciplinary teams that include social science researchers, to solve complex societal challenges (Palmer et al. 2016), based on the guidelines from a range of proposal calls by the National Science Foundation (NSF), U.S. Department of Agriculture (USDA), and other funding sources.[1] Agricultural and Applied Economists are likely to be recruited into these teams to perform economic forecasting, simulations, experiments, benefit-cost analysis, or a combination of social-economic-environmental impact assessments (Mooney et al. 2013;

[1] The National Socio-Environmental Synthesis Center (SESYNC) has hosted several workshops on this topic and has additional useful information that you may wish to access. For example, the SESYNC Networks of Networks Workshop: https://www.sesync.org/project/propose-a-workshop/sesync-networks-of-networks-workshop.

Hertel 2020), or that may lead these teams. There are many evolving new and exciting opportunities for Agricultural and Applied Economists to contribute to broader scientific discoveries and transform knowledge into practice.

Interestingly, the knowledge and skills to successfully pursue grant funding has not been incorporated into a formal curriculum for post-bachelor's degrees across the social sciences, including Applied and Agricultural Economics. The exposure to training or mentoring in grant writing during early career development may depend on whether your PhD supervisor involved you in grant writing or your institution offers you a grant-writing workshop. The ability to conduct research within the bench sciences and engineering is heavily dependent on access to external funds, and graduate and postdoctoral experiences and training to pursue external funds are much more readily available in these areas, than in many social science programs (Kahn et al. 2016). Such opportunities can increase confidence and familiarity with individual and team-based proposals (Wallen et al. 2019). Early career scholars and assistant professors in agricultural and applied economics often face challenges because of a lack of training and mentoring. They regularly express uncertainty in dealing with confronting elements of writing grant proposals. These may include where to find relevant grant programs, what are elements of a successful grant proposal, how to establish validity for your research capabilities, insights into creating and managing research teams, and effective ways to learn from rejection, being able to transform near-term failure into long-term success. Few new and emerging scholars appreciate key differences between multidisciplinary, interdisciplinary, and transdisciplinary proposals. Many social science scholars are also uncertain how to join a grant-writing team at the ideation/inception stage and/or join teams later that have not involved them in the inception of the research idea and planning process of a proposal.

This article provides user-inspired insights into grant writing, including strategies and step-by-step guidance for early career scholars and grant seekers to prepare, plan, and complete an effective grant proposal. Much of the information is generally applicable to single investigator and small team proposals even though the focus is on proposals created with interdisciplinary teams. This article's authors have broad experiences serving as Principal Investigator (PI), Co-Principal Investigator (co-PI), or Program Officer (P.O.) for several grant funding programs. Whether a grant proposal is successful or not depends on many factors, including the quality of the ideas, responsiveness to the funders' needs, ability to clearly and compellingly articulate complex ideas, the composition of grant review panels and funding agencies' priorities and assessments, among many other factors. Given the strong demand for grant-writing supports, the purposes of this article are (1) to articulate and demystify the process of grant writing and (2) to share a list of practical recommendations based on varied and beneficial experiences and skills of scholars who have broad experience in writing, selecting, and administering grant applications.

2 Preparing for a Grant-Writing Mindset

What, Why, Who, How, and So What? Each scholar seeking grants needs to begin with an in-depth self-assessment to identify career interests, capabilities, and goals. One useful approach is to conduct a SWOT (strength, weakness, opportunity, threat) analysis to establish your overarching grant-seeking strategy, and then to implement your strategy using a SMART (specific, measurable, actionable, realistic, time-based) approach (Liang et al. 2019; Liang 2019; Liang 2020). Applying for grants may occur at any stage of the career for individuals working in academia and private/public organizations. For example, a junior researcher is likely to be more interested initially in establishing recognition and credentials through successful grant applications that result in peer-reviewed articles to achieve tenure and promotion. In contrast, a senior researcher is often more motivated to seek grant support that can generate deep disciplinary advances or broader disciplinary-crossing impacts through innovation and novel ideas by taking higher risks.

To submit a competitive grant proposal within the typically short window between a call for proposals and submission deadline, a scholar must have a mindset of preparedness and readiness. One

good practice is to develop and maintain a list of potential grant ideas, including corresponding references based on personal knowledge, skills, and interests that could be transformed into grant proposals building on historical trends, current affairs, and futuristic predictions. Scholars who plan to write grant proposals need to develop ideas that meet the need and program priorities of grant opportunities. Seasoned grant writers often maintain a broad and comprehensive literature review based on their interests, knowledge, skills, and goals. Frequently updating, accessing, and reading contemporary reports, news releases, and peer-reviewed publications from professional and reliable sources is always a good exercise for us to become familiar with existing knowledge and practices.

Attending conference sessions or accessible conferences beyond a researcher's immediate capabilities and knowledge base can stimulate new perspectives that evolve existing approaches or encourage use of novel tools and approaches to tackle emerging challenges. These exercises encourage a grant writer to become exposed to unconventional and innovative concepts while creating a good list of references ready to use when a suitable grant opportunity becomes available. This practice is also useful for supporting efforts to write and publish journal articles. The synergy between publishing and grant-writing activities is an essential consideration in time management and career development. Participating in professional meetings and workshops is also an effective way to learn from other scholars who have been successful in interdisciplinary grant applications.

Beyond learning from the contexts and contents in professional meetings, it is beneficial to pay attention to presenters who are agricultural and applied economists contributing to interdisciplinary studies. Good questions to consider are (1) what types of interdisciplinary studies are likely to involve agricultural and applied economists; and (2) what objectives and activities agricultural and applied economists contribute to an interdisciplinary project? Many people think that economists must deal with "numbers." Agricultural and applied economists are a very diverse cohort covering many subjects concerning data, experimentation, modeling, analytics, logic, training, demonstration, and evaluation. Common requests made to agricultural and applied economists are to conduct some cost-benefit analysis, survey, financial analysis, or trend analysis. This reflects a small subset of our skill set and a gap in the knowledge available to other disciplines between what we are perceived as doing versus what we can do. A useful strategy to increase engagement and understanding of our skill sets is to do a better job of promoting our talents, knowledge, and skills by widely publishing and presenting in interdisciplinary professional settings. A growing number of professional associations welcome scholars to present interdisciplinary papers or conduct workshops to promote collaborations. The U.S. Association for Small Business and Entrepreneurship (USASBE), National Small Business Institute (SBI), Food Distribution Research Society (FDRS), Institute of Bioengineering (IBE), Soil and Water Conservation Society (SWCS), American Public Health Association (APHA), Community Development Society (CDS), American Geophysical Union (AGU), and American Water Resources Association (AWRA) are a few good examples.

A common complaint about grant writing relates to time management and trade-off associated with writing peer-reviewed articles: "this takes time away from writing papers." While writing papers and writing grants have their differences, there is also a complementarity in these activities. A scholar needs to treat grant writing as a continuum, because successful grant applications lead to peer-reviewed publications. The critical thinking and topical research required to develop a competitive proposal frequently leads to more effective conceptualization and articulation of in-process or recently completed research that can improve preparation of manuscripts for submission. A strong grant portfolio is critical in committee's consideration of a candidate for tenure and promotion. Many external letter writers will comment if there are no attempts to pursue external grant funding and tend to make favorable comments about candidates' efforts to secure funding (even if unsuccessful to date) and the candidate's ability to support their research.

Writing a grant proposal is different from writing a journal article (Porter 2007). Writing a journal article usually demonstrates personal interests in the subject, narrates completed research process and outcomes (e.g., data collection and results of data analysis), and explains research information to an

audience who might share a similar passion in specific topics. However, a grant proposal serves the sponsor's interests and priorities, depicts the research process needed to be done, illustrates necessary data yet to be gathered and analyzed, and markets the idea directly to reviewers and sponsors to fulfill future purposes and missions. In many ways, a grant proposal is like a sales pitch. We all care about our research agenda. To succeed in grant writing, we need to convince the sponsors that we care about their agenda and have the ability and capacity to meet their needs and funding priorities successfully. A bonus point to share—many successful grant writers can convert the critical components in a grant proposal into journal articles to share novel theoretical frameworks, data discovery, integrated analytics, and creative partnerships.

What Is Interdisciplinary? Grant topics could focus on research, teaching, and/or outreach and service. Some grants involve a combination, or an integration, of multiple areas. The number of requests for proposals that involve multidisciplinary, interdisciplinary, transdisciplinary, and convergent approaches has increased recently. These terms are often used interchangeably without a clear differentiation between them. Growing interest in research that crosses disciplinary boundaries has provided clarification about each of these terms (Choi and Pak 2006; Harvard Transdisciplinary Research in Energetics and Cancer Center; Integration and Application Network 2017; Vagios 2017):

- A multidisciplinary grant proposal has the nature of combining or involving several academic disciplines or professional specializations in approaching a topic or problem. Everyone in a team brings in training, experiences, and skills that could add value to a joint effort of problem solving. For example, a team is working with farmers to deal with marketing issues by transitioning from face-to-face sales to eCommerce. This team may consist of scholars specializing in website design, product categorization, visual communication, pricing and cost assessment, payment scheme, and data security.
- Interdisciplinary studies involve combining and integrating two or more academic disciplines into one grant proposal to create a process or strategy across problem-solving boundaries. Individuals contribute specific skills, knowledge, and experiences to integrate with and build on others' abilities and capacity while achieving common goals and objectives. For example, a team is committed to improving food accessibility and affordability for residents of food desert communities. The scholars involved in this project would include economists (for market location assessment), geographers (for transportation assessment), and engineers (for data analytics and alternative food supply chain design).
- Transdisciplinary efforts describe research, teaching, and/or outreach and service initiatives proposed by "investigators from different disciplines working jointly to create new conceptual, theoretical, methodological, and translational innovations that integrate and move beyond discipline-specific approaches" for problem solving (Harvard Transdisciplinary Research in Energetics and Cancer Center; Integration and Application Network 2017). For example, a team is working on designing, developing, and implementing a novel framework to create a Smart Community where residents would enjoy an upgraded infrastructure of data exchange supported by futuristic tools, devices, and applications.
- A convergent research defined by the National Science Foundation (NSF 2021) represents "a means for solving vexing research problems, in particular, complex problems focusing on societal needs. It entails integrating knowledge, methods, and expertise from different disciplines and forming novel frameworks to catalyze scientific discovery and innovation." One of the current NSF Call for Proposals identifies convergence research involving two primary characteristics as described by NSF on the website (NSF, 2021):
  - *Convergence Research is generally inspired by the need to address a specific challenge or opportunity, whether it arises from deep scientific questions or pressing societal needs.*
  - *As experts from different disciplines pursue common research challenges, their knowledge, theories, methods, data, research communities, and languages become increasingly*

intermingled or integrated. New frameworks, paradigms, or even disciplines can form sustained interactions across multiple communities.

The following sections will discuss different strategies to explore and nurture the grant-writing mindset, grant-seeking approaches, and effective team-building dynamics and situate these suggestions within the four phases of Decision Emergence Theory (DET). Each section below includes knowledge, experiences, and recommended perspectives from the authors, with a specific emphasis on team-based grants. The information should not be generalized to provide a "one-size-fits-all" solution to all the grant applications. Rather, we intend to present a broad view and offer insights that will help grant applicants in the agricultural and applied economics fields to overcome some challenges and barriers.

3 Seeking Grant Funding Programs

If you work for a higher education institution, the best place to look for grant opportunities begins with your institutional office of sponsored programs or other university unit in charge of supporting faculty applying for external grants. Most higher education institutions maintain an updated list of grant opportunities, offer grant-writing training and assistance to clarify grant opportunities, identify grant program priorities, and construct grant proposals and related documents such as budget development, mentorship plan, and data management. Grants can take a long time to write, especially if a large team needs to be assembled. As mentioned earlier, due dates for many programs tend to follow similar patterns each year. It can help start tracking due dates each year and maintain a calendar that contains your best estimate of each due date, so you are already thinking of the opportunity and starting to plan time in your day/week/month to create your proposal. Many researchers use an option to sign up for notifications of recently released grants using a database such as COS[2] Pivot, developed by ProQuest. Many university libraries or offices of sponsored research subscribe to this database. It includes federal grants, state grants, and many opportunities from philanthropic organizations, all of which could be opportunities suitable for your work. Individuals can set up keyword searches to seek funding opportunities with characteristics that match or overlap with your research area. Once a profile has been established, weekly (or daily) emails are sent directly to you that contain funding opportunities with your selected keywords. This is an excellent resource to become aware of new Requests for Funding Proposals (RFPs) that you had not previously seen and a reminder about upcoming opportunities you were thinking to target. Another source of information at the early stages of familiarizing yourself with grant opportunities is to talk to colleagues with similar interests about their experience with funding agencies and programs that they might consider suitable for your work.

3.1 Government Agencies

The most popular and comprehensive website about federal grants is www.grants.gov. There is a Grants.Gov mobile app for searching and submitting grants on the go. This website or app contains information to assist applicants searching for grants and tips and suggestions for individuals or teams to write proposals. It incorporates several services to guide applicants through the grant-writing process and get familiar with the grant-making agencies and policies. Clicking on the option "Search Grants," the applicants can choose different options to review relevant grant opportunities offered by different federal agencies based on various eligibilities and categories, and/or closing dates.

For research relevant to agriculture and the environment, state agencies are a fruitful source of potential funding opportunities. Pursuing funding from state agencies is an important avenue to consider as competition increases for a fluctuating (and often decreasing in real dollars) pot of available federal funds. State agencies are tasked to solve emerging and ongoing regional problems using cost-effective approaches to satisfy regional stakeholders that may include the agency, the voting public, and often related state agencies. Agency officials are eager to identify researchers from in-state universities with

[2] Community of Science.

relevant expertise and a passion for addressing problems that impact their communities and state. Useful solutions are often nuanced by regional differences best understood and accommodated by a researcher from a local institution. Relationships developed with officials at state agencies can develop over the years to become long-lasting mutual benefit sources for the agency and faculty members in collaborative research opportunities. Such interactions may also offer future employment opportunities in the region for participating undergraduate and graduate students. Alumni so placed become vocal advocates for continued interactions with faculty researchers at the home institution.

Besides, many institutions offer (often smaller) internal grant opportunities. These are excellent opportunities to obtain small amounts of funding to develop data sets or ideas that can build toward submitting a more comprehensive, external grant proposal. It is common for there to be opportunities for early-career investigators. The probability of success with these programs is generally higher than with federal funding agencies. Some offer a chance for feedback on your proposal, which can help increase your skills in this area.

3.2 Industry Grants

It is advisable to consider funding opportunities from different sources as government grants are not always available. University research has been increasingly supported by industry as funding has generated technology-based economic activity at the state level (Atkinson 2018). Atkinson's report reveals that the industry funding share varies considerably between states, from a high of 12.1 percent in North Carolina to 1.7 percent in Nevada, with North Carolina, Georgia, Kansas, Ohio, and Missouri as five leading states for industry funding.

Collaboration with industry is a unique opportunity to see that your research has real-world impact and meets your institution and students' demands, with the latter specifically interested in research experience that leads to jobs right after graduation. However, before seeking this funding type, it should be noted that industry-sponsored research is often applied or Research and Development (R&D) and may not be as intellectually stimulating or scholarly as federally supported, long-term fundamental research. Also, industry contracts impose different pressures on timelines and specifications and may have a different set of interests and criteria than federal and state grants. Industry funding should be treated as a business activity vs. a federal grant. One additional caveat associated with industry grants is about potential restrictions for the publication of research in academic journals. Depending on the funder and solicitation specifics, an academic researcher might need to forfeit their "bragging rights" about the results of industry-sponsored research as all or part of the work completed on such a grant becomes the intellectual property of the funder. The inability to publish the results in academic journals could be detrimental to the promotion and tenure processes as many applied and agricultural economics academic departments place a higher value on peer-reviewed publications than on grant-writing success (Todd 2013; Schroeter and Anders 2017).

Thus, it is crucial to consider the university's policies and guidelines to work with industry partners to identify and agree upon proper research agenda and dissemination of research results that might not be allowed to publish in academic journals due to confidentiality rules. For this, one should find companies working in his/her field of interest, asking them what they need and would like to work on to meet their criteria, and consider their interests. Several benefits are possible in working with industry, particularly those local to the university. Some of these benefits may not be readily apparent at first glance but tend to emerge over time as trust develops between industry research champions and the university researcher. For example, an industry may be motivated to attract or retain an exceptional new hire or employee by offering graduate education support. Depending on each institution, it may be possible for graduate tuition and fees to be paid by the industry sponsor and time provided (sometimes during regular work hours) for the employee to complete graduate courses and conduct research. Such a situation can support a productive, motivated graduate researcher without requiring a graduate stipend on a mutual interest project to the company, graduate student, and faculty member.

4 Matching Your Proposal Idea to a Program and Funding Agency

Federal funding agencies differ in their review process, the type of work they are looking for, and their expectations about pitching your ideas. For example, proposals to the NSF compared to those to the USDA differ considerably. As examples, NSF places significant emphasis on the transformative aspects of fundamental or basic research in unsolicited proposals. USDA often prioritizes research funding for proposals that have potential for broad impact in constituent communities, particularly through existing research networks and extension mechanisms.

The requirement to demonstrate broader impacts in each NSF proposal may go beyond expectations for research-based recommendations to other federal agencies in areas of, for example, professional development and dissemination. Similarly, proposals to a philanthropic foundation or industry can also be written in a very different style. When first starting to write grant proposals, we suggest that you focus on one or two outlets and spend time learning about the characteristics of what makes a good proposal for that funder. Good advice for proposal writing to a particular program at any stage of one's career is to contact the program officer, provide a short description of your research capabilities and interests, and participate in a review panel for proposals in that program. A good time to do that is shortly after you see the RFP released. Soon after release, the program officers will be devoting time to securing reviewers and organizing the panel dates. Participation as a panel reviewer will familiarize one with the "norms" for that program. Other panelists are likely to share your interest in the area and may be open to collaborating on a topic of mutual interest in which each brings complementary capabilities. Once you have regular success, it is easier to write for a wider variety of funders. Or, possibly, if you have no success, you might have chosen the wrong funder and should move on.

Funding amounts also differ considerably (see Table 1) as do success rates. It is essential to "right-size" your initial grant submissions. In general, multi-million dollar large and complex team grants (such as Engineering Research Centers or Science and Technology Centers) are not led by junior faculty or investigators with little grant writing and team management experience. However, these efforts might be an excellent way to become part of a larger team or seek smaller awards that do not require a larger team's management. A good strategy is to map out possible programs for your work and think of these as a continuum over time as you build smaller to larger awards. This is not required for all research, though, and you may spend your entire career working in smaller teams that are well funded by smaller awards.

Table 1 illustrates a range of awards in terms of duration (years) and size (typical annual budget) available from different NSF programs. Also noted is the funding cycle or frequency for offering the awards. Additional detailed information can be obtained through the NSF Budget Division web site (https://www.nsf.gov/bfa/bud/) and accessing the Budget Internet Information System (https://dellweb.bfa.nsf.gov/) designed to be an information resource for award summaries and NSF funding history.

Expectations for the content of the proposal vary, depending on the program and size of the award. For example, at the level of a research center, the proposer should be prepared to address questions in the proposal, such as:

- What is the innovative idea, and what important societal need does it address?
- How will the proposed project enhance the foundational sciences across disciplines?
- What is the compelling working hypothesis for the proposed approach that addresses this need?
- What is the value (benefits vs. costs) for society from this approach?
- Why is the new value significantly better than the competition and alternatives?

As you and your team members tackle these questions, be sure to reach out and talk to the Program Leader or P.O. of the program that has issued the RFPs to which you are responding. Prepare a one-page concept note describing the proposed team effort as it responds to the RFP in the context of the

Table 1. Types of National Science Foundation Awards Available Across a Range of Programs in 2020

NSF Program	Award Budget ($)	Duration (Years)	Funding Cycle (Years)
Engineering Research Center	10,000,000	5	2
NSF Research Traineeships	600,000	5	2
Emerging Frontiers in Research and Engineering	500,000	3	1
Industry/University Cooperative Research Center	150,000	5	1
Standard Grant	300,000	3	1

Data Source: NSF publishes and announces funding allocations each year by programs. The information is available on the NSF website for those who are interested in finding funding allocations.

above questions. Ask the P.O. if this proposed concept would be a good fit for the program. The P.O. and their colleagues, with assistance from their program staff, craft the RFPs and assemble panelists for the review panel. In doing so, they may ask people who have applied for grants in the past and consider people who ask to be a reviewer among other sources. Before submitting a proposal to a new program, it may help to participate as a panelist on a panel review for the program to familiarize yourself with program norms—expectations that the P.O. and panel have for proposals seen as responsive to the RFP. It is suggested that you contact the P.O. as early in the proposal development stage as possible, at least 60–70 days before proposals are due, to indicate that you would like to be considered as a reviewer. Include your resume, web site address, and a brief list of your expertise areas to help the P.O. understand if your expertise is a good fit. Do not be discouraged if you are not immediately accepted; keep trying to get this experience both in future submission dates and similar programs.

5 Strategies for Team Creation and Communication

Writing a team-based grant proposal is a complicated communication process (Bordage and Dawson 2003; Dopke and Crawley 2013; Velarde 2018). Developing the proposal may take a few months to a few years, beginning with initiating the ideas, gathering supportive evidence from preliminary studies, designing innovative approaches for problem solving, and convening stakeholders' inputs to strengthen the broader impacts. Some grant writers act as single PIs, while most of the funding agencies request team applications. A single applicant's advantages are: (1) acting as a free entity without negotiation and compromising with other's opinions, and (2) fully controlling the proposal and budget development. The team collaboration, however, provides benefits to (1) stimulate intellectual activities to potentially uncover new knowledge and practices that might impact multiple disciplines, (2) reduce stress and pressure to complete a grant proposal when properly sharing tasks and responsibilities, and (3) elevate the scope of research, teaching, and outreach programs with broader connectivity.

The timeline between the RFP release to submission deadlines is usually between 60 and 90 days. Adequate planning and preparation are essential for grant-writing success, particularly for team collaboration submissions. Many RFPs are released on relatively predictable cycles, allowing an

individual or team to plan and work on drafts of their ideas for more extended periods. It is important to cultivate interdisciplinary collaborations well in advance of the release of an RFP. There are many methods to do this, but in general, it involves making the effort to make a connection, explore if there are shared interests, appropriate time availability, and a fit in styles and personality. Common ways to "get to know each other" are through Zoom or other meetings, as well as an informal meeting such as over coffee or a meal. An invitation to guest lecture to your class and co-advising students are among many other opportunities for connection.

Fisher (1970) introduced a Decision Emergence Theory (DET) that involves four phases of group decision making. The DET could serve as a useful guide for early career scholars as they plan, prepare, and draft a grant proposal effectively with a team (Dopke and Crawley 2013). A summarized interpretation of a team grant-writing approach using the four phases of DET is as follows:

- Phase 1—Orientation

  This phase represents the initial team organization and connectivity. This phase emphasizes team members' general agreement to a high-level of understanding and agreement to the proposed ideas, research questions, plan of work, collective and individual responsibilities, and timelines and deliverables. Team members will get acquainted with each other and learn from each other about knowledge and skills corresponding to the proposal's needs. Individuals will reveal some personalities and express polite opinions during the team meetings in this phase. Team members must get a sense of potential tension or ego across the individuals while moving forward to write the grant proposals.

  This is also an excellent time to engage with your university-sponsored research office and let them know you are beginning to engage in proposal preparation discussions. The research office could assist by identifying prior submissions from colleagues to the program (or similar programs) and securing copies. These can provide useful guidance for how to present content and degree of detail. In some instances (often depending on resource availability at the institution), they may be able to connect you with a staff grant writer, or a list of writers that the university has commonly used that you could contract with if you had professional funds available.

- Phase 2—Conflict

  This phase represents a dynamic between team members after everyone has a chance to share voices and perspectives. There might be some arguments, disagreements, and persuasions exchanged among individuals. Most of the conflicts arise from struggling to achieve mutual understanding or buying-in about the overall goals, objectives, and specific project-related activities. Some contests would also link to budget distribution and credit allocations among individuals and partnering institutions. The leader(s) of the proposal would surface naturally or by team members' choices in this phase. The leader(s) may or may not serve as the lead PI(s) for the team. The leader(s) often leads in the technical design and development of the proposal or takes charge of the team management by delineating tasks, deadlines, and deliverables diplomatically.

- Phase 3—Emergence

  Team members should achieve a sense of collegiality and refrain from attacking and rejecting others' ideas without due consideration. Some debate and spirited discussion are expected, and respectful disagreements may occur. It is important to hear out reasoned arguments and work to create a common understanding of the problem, vocabulary, and overarching aims. The leader(s) would facilitate discussion among groups to weigh the pros and cons of various options while negotiating for goals, methods, and budgets. There will be some ambiguity regarding the proposal development in this phase, and team members should feel comfortable seeking alternatives if necessary. Given the proposal submission deadline's pressure, team members will be more likely to

set aside personal issues and abide by a cohesive decision. According to Fisher (1970), teams collaborating on grant writing might spend most of the time in this phase, until issues are resolved, and everyone is willing to move on by reaching consensus or agreement on the choices made that all members respect.

Recently, the National Research Council (2015) identified a useful set of best practices that can guide multi-, inter-, and transdisciplinary research teams. They identify three common areas that benefit from early clarification and help to reduce conflict and support team emergence (DET phases 2 and 3) in addition to suggestions that support team formation and identification.

a) *Standardize vocabulary:* A common vocabulary is necessary to smoothly integrate data, tools, knowledge, and theories across disciplines. This will significantly improve understanding in areas that are not been commonly shared across fields and will help to avoid confusion. A shared vocabulary referred to as a trading or pidgin language facilitates interrelation of subsystems that cross traditional disciplinary boundaries in a broad conceptual diagram of a transdisciplinary system (Alberti et al. 2011).
b) *Attribution of credit:* Clear guidance for how credit will be attributed across team members and how participation will be assessed and recognized. There are many team-based work tools available that can track participation and contributions to meetings, data collection, analysis, and manuscript preparation. For example, Google Docs is a common tool that tracks individual input as is Track Changes mode in Microsoft Word. Some teams may want to create a team log that updates workload and outputs. In addition, Google Docs allows working with other team members concurrently when changes made go live instantly, and there is no more wondering who has the latest version of the proposal.
c) *Training in knowledge development:* Communication effectiveness can be increased by engaging the team in facilitated opportunities for dialogue that aim to increase individual knowledge sharing and improve problem identification and solution generation. Facilitated conversations can significantly alleviate tension and improve collegial efforts.

Further areas that benefit from early clarification are the norms and expectations for using project data and resources in other projects; what manuscripts are planned first and who are the likely team members contributing to these manuscripts.

▶ Phase 4—Reinforcement

This is the last phase in teamwork and occurs close to the proposal submission deadline. A team engaged in effective collaboration should by this point have reached an agreement about all aspects described in the proposal, checked, and validated supplemental documents required by the funding agency, and completed subaward packages as required by the lead institution and the funding agencies. Each institution involved in the proposal usually requests between 7 to 10 days for internal review and to process the subawards. It is critical to keep in touch with the office of sponsored programs at the lead institution and receive detailed instructions about a subaward institution's required paperwork. It is always a good idea to complete the subaward package as soon as possible to avoid delays in submissions. The PI usually shares the confirmation of submitting a grant package with team members and should follow up with future communications with the funding agency program leaders. A post-submission follow-up with proposal team members to reflect on the teamwork, planning, and application process is strongly recommended. This activity presents an opportunity to get ideas for improving the experience of early career investigators and inclusiveness, and to receive other suggestions for future process improvement. As there is a range of power dynamics with teams, the leads may wish to consider setting up a system for deidentifying comments.

DET theory provides one path for collaborative grant writing. It is not necessarily true that every team goes through the same phases each time. Each phase is an interactive process within the team, and each team may go through each phase multiple times throughout the grant-writing process. There is no guarantee that each team member will be completely satisfied with the proposal development just because the team reaches a consensus. Each member often needs to weigh the pros and cons in this process and make educated and informed decisions to stay with the team or depart.

The National Research Council (2015) suggests using research networking systems to facilitate the assembly of partners well-suited to tackle a particular research concept, as well as applying task analytic methods to identify knowledge, skills, and attitudes required for effective team performance.

6 Establishing or Joining an Interdisciplinary Team

The good news (for applied economists) is that many federal granting agencies such as NSF and USDA encourage and sometimes require social scientists' participation and leadership of interdisciplinary projects. Federal agencies are tackling grand challenges and so-called wicked societal problems that can benefit from consideration of bio-physical systems and processes within a larger policy or societal context. Over the last several years, new programs have been developed that broaden the opportunities for economists to lead and participate in teams seeking federal funding. Some recent examples from NSF are: Dynamics of Integrated Socio-Environmental Systems (DISES),[3] Innovations at the Nexus of Food, Energy and Water Systems (INFEWS),[4] Human Networks and Data Science (HNDS),[5] Accelerating Research through International Network-to-Network Collaborations (AccelNet),[6] and several opportunities within the Established Program to Stimulate Competitive Research (EPSCoR),[7] among many others. The USDA also offers many programs, for example under the Agricultural and Food Research Initiative (AFRI).[8] Many other agencies, for example, Department of Energy, NOAA, and NASA also provide opportunities to include social science within some of their proposals. So how do we, applied and agricultural economists, make ourselves known and start joining or establishing potential interdisciplinary teams?

Accessing the institutional database about research interests and funded projects and reaching out to the deans for research and university research office lets one tap into the resources available at your institution. Attending seminars at the home institution in other departments helps identify potential collaborators and learn about contexts and their studies/methods. A route that worked for this paper's authors is to attend and present at multidisciplinary conferences related to the faculty's research interests. For example, applied economists working on environmental problems might present at the meetings focused on water or soil conservation topics such as those organized by SWCS, AWRA, or AGU.

Initial conversations with the scientists from other disciplines (DET phase 1) may require becoming (temporarily) an economics instructor, as more often than not, researchers outside of economics are not thinking about the broad concept of opportunity costs and might have limited understanding of what economic analyses could bring to the table. When approaching potential colleagues from other disciplines, a useful strategy is to set your mind to be ready "to teach" Economics 101 and "be taught" non-Economics disciplines 101. Different sciences speak different languages and have different norms. Phases 2 and 3 of DET focus on strategies for and the importance of creating a shared understanding. For example, disciplines have a differing understanding of what constitutes a good model: an R^2 of 0.7 might be intolerable in some controlled agronomic experiments, but could be considered an excellent statistical fit for an econometric model estimated using cross-sectional data. Such

[3] https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf20579
[4] https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf18545
[5] https://www.nsf.gov/publications/pub_summ.jsp?WT.z_pims_id=505702&ods_key=nsf21514
[6] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505584
[7] https://www.nsf.gov/od/oia/programs/epscor/
[8] https://nifa.usda.gov/program/agriculture-and-food-research-initiative-afri

disciplinary differences are generally not common knowledge and putting yourself in a learner and educator mode helps start productive communication, which in turn helps establish a grant-writing team. Another potential strategy is to seek co-advising graduate students working on research that is of interest to two or more collaborators from different disciplines. Such advising collaborations provide an additional benefit that is likely to help with future grant applications by developing joint, co-authored publications and what could be considered as preliminary data for the research to be proposed.

An important consideration for early-career academic researchers is to weigh perspectives from mentors, colleagues, and leaders in their academic unit (department, college) and institution about valuation of multi-, inter-, or transdisciplinary collaboration in the advancement and tenure process. Valuation of an early-career investigator's contribution to discipline-crossing collaborations relative to primary-authored proposals and publications can vary substantially between institutions and among peers within an institution (Alberti et al. 2011). Whether potential interdisciplinary benefits of building a broad collaborative network that generates synergistic advances and contributes to outcomes whose impact is recognized across several fields are justifiable from a career advancement perspective depends on the academic institution. Given the typically lengthened development phases and lessened individual credit in multidisciplinary projects, the finite timeline for early-career advancement should be discussed with an early investigator's supervisor(s) and advancement committee before initiating such collaboration. The grant-related choices such as determination of authorship credit, proposing to write a sole or first-authored article that leverage group efforts, or sharing of proposed or received budgets, influence the time to the outcomes that are evaluated for promotion and tenure. The proverb, "If you want to go fast, go alone. If you want to go far, go together" has relevance here.

Once the team starts forming around a research theme or topic, continuing identification of mutual interests and open and honest communication cannot be overstated. As mentioned earlier, not all applied economics departments value grant writing as much as peer-reviewed publications. The opposite might be right for many science and technology departments. Clarifying early on which grants (amounts, funders) are valued most and which ones are sufficient for a start will help understand the motivation of individual interdisciplinary team members. Not every proposal needs a big team. The members' career advancement considerations could influence the grant for which the team decides to apply, the number of collaborators, and budget size.

In addition to the open discussion about the importance of specific grants, publishing priorities are not always self-evident in teams. Two aspects of team publishing worth noting: one concerning any team publishing, and the other—specific to interdisciplinary teams. For any team, misunderstandings about roles, responsibilities, and credit attributions are common contributors to the dissolution of promising research collaborations. Early on in your collaboration and partnership, initiate a discussion about these aspects of proposal and publication development. Several valuable resources are available from, for example, writers (Albert and Wager 2003; Herz et al. 2020; Oliver et al. 2018) and publishers (Elsevier 2019), highlighting essential considerations in collaborative publication and providing a framework for discussion and rubric for establishing expectations about attribution and other aspects of copublication.

Publishing by interdisciplinary teams endures additional challenges. Publishing in economics journals could be taxing, especially when the economists have the ownership of data and research process because economics journal impact factors are generally lower than those in other disciplines. Open communication about how the paper authorship is related to grant and identifying target journals early on help avoid conflicts and disappointments when researching for publication opportunities. Again, different disciplines have different conventions and values assigned to single- versus multiple-authored publications, the authors' order on a paper, peer- reviewed conference proceedings, papers published in interdisciplinary outlets, and other publication issues. An open discussion and clarification of these differences are needed.

A second factor to consider are the incentive and reward structure in your own department. It is

important to understand if work published in interdisciplinary journals or journals outside of your discipline is valued and rewarded by your unit (Haider et al. 2018; Mooney et al. 2013). If it is not, we encourage you to be clear about the elements of the project that will enable you to create the types of scholarship that is rewarded by your unit, or consider transferring to a school that is open to you pursuing the scholarship that interests you.

Finally, when it comes to writing the proposal, project leaders must be effective managers and establish and maintain personal contacts and continue to reinforce excellent communication and management practices (DET phase 4). Strong leaders bring people together for planning meetings, make sure people understand what is happening, keep up with the deadlines, encourage interactions and venues to exchange information and share progress, and give intellectual buy-in early on to motivate collaboration and productive relationships. At the stage of proposal development, starting with broad concepts, leaders must identify potential individuals to complete specific tasks and activities, and to acquire a consensus with colleagues before confirming assignments. As with research itself, we all have our up and down times. In terms of effort, consistently maintaining progress with the proposal is no different from consistently maintaining a research project.

7 Understanding Proposal Development and Review Process

Most federal grants are solicited through an RFP.[9] The RFP outlines what the program is looking for (types of science, topic areas, etc.), the amount of funding available, any limitations about individuals or institutions that can apply, and the review criteria. If you are not sure that your idea fits with the program, look for opportunities to attend webinars or other information events, where program officers talk about the needs of the programs and may answer general questions about the intent and what they are expecting as well as any significant considerations that would make your proposal more responsive to the RFP. Program officers at some programs are willing to talk with you about your ideas and suggest appropriate programs that might be a good fit. This is particularly the case for early-career faculty. The RFP may also contain specific information to be included in the proposal as well as font size, requirements for a bio, conflict of interest, current/pending funding and commitments, headings of each section, page limit, attachments, and so on. Proposals can be (and are) rejected by the funding agency, without review, if they are not compliant with formatting and page limits. Many early investigators might underestimate the strict adherence to the formatting guidelines, particularly by federal funding agencies. We encourage you to take this very seriously. We can assure you they do! It is disappointing to spend several months on a grant proposal to have it rejected without review because it is too long, the font size is off, a required section is missing, or some other formatting reason.

Some institutions have resources available to help investigators collate, format, and check compliance of their grants. If these services are not available, we suggest that you carefully read the formatting and other requirements and then check your own work or enlist the help of colleagues and collaborators. This activity takes time, is not that complicated, and can be successfully accomplished without professional help if the grant does not involve many institutions and lots of personnel.

As the requested amount increases so does the complexity of the proposal (in general), as larger grants might require services of a professional manager or sharing other support personnel (e.g., communication professionals) with other externally funded projects. If the grant size is significantly large (e.g., over $1 million), consider working with a professional proposal development consulting team or hiring a proposal manager through the institutional Division of Research's assistance if these services are available to you. These services increase the ease of creating the proposal, but many investigators complete their submissions without such support.

Writing a strong and well-crafted proposal will take significant attention, thought, and time. Like

[9] Sometimes referred to as a "solicitation" or request for applications (RFA).

writing successful journal articles, proposal writing is a learned skill that improves with practice. We encourage early career investigators to focus on one project and create a highly competitive proposal rather than spend time superficially working on several proposals that may lack focus or polish. It is also important to assess the skills of the team you are joining in this regard. If joining a large team, look for one where the PI has strong organizational skills and a good track record of prior funding. Contributing a smaller part to a large and well-run proposal is a great way to learn more about the process and good practices for organization, timing, team management, and writing. Earlier we noted that there are many agencies that offer opportunities for social scientists to propose and receive funding for their work. One important consideration is that each agency has slightly different expectations regarding presentation of material and the focus of the work that they fund. These differences are significant enough that early career investigators will benefit from pursuing funding from a single or possibly two agencies initially until they are familiar with their expectations before seeking broader funding support.

Most grants are reviewed by groups of people either in a panel or several *ad hoc* reviews (or a combination). Reviewers often read several proposals for the same program (sometimes as many as 20), which can be very time-consuming. The reviewer is unlikely to read your proposal several times, and as such, it is important to be clear and concise in your writing and presentation of ideas. Inexperienced grant writers tend to provide too much information in background and rationale and fail to describe detailed scientific merit in limited space. Creating explanatory graphics, color coding elements, and highlighting key proposed activities and impacts are some examples to help guide the reviewers through your ideas. Explanatory graphics that lead the reviewer through the main ideas of the proposal (particularly the complexities of a multidisciplinary proposal) are very helpful to convey complex ideas to a broad array of reviewers who may have expertise in one element of the proposed work but need to understand how those elements tie in with the larger project. Some institutions provide help with graphics to improve the look and readability of proposals. Several freelance graphic creators specialize in research graphics. Each institutional sponsored program likely can help you find a graphics professional; another option if to reach out to colleagues and ask them for suggestions and names. Possibly the best way to learn how to write a compelling proposal is to work with other researchers that are experienced grant writers and/or read other successful and unsuccessful grant proposals. As mentioned earlier, an excellent way to see many proposals at one time is to volunteer to serve on a grant review panel. This experience will quickly provide you with a lot of information about common criticisms and innovative means to propose and explain research ideas. The most benefit can be gained by volunteering to review at agencies and for programs that you intend to submit to in a later year.

8 Turning Failure into Success

What contributes to rejection of a proposal for research funding? Multiple factors can contribute, some of which are similar to the reasons behind papers' rejections in peer-reviewed journals. However, with grants, there are additional, important possibilities:

- The proposed topic and orientations do not match with the program's priorities.
- Not all the specific review criteria identified in the request for proposal were addressed.
- The proposed research lacked one or more factors deemed necessary to achieve the targeted outcomes, e.g., resources, methods, expertise, or contingency plans.
- The overall presentation of the proposal lacks clarity, consistency, and purpose.
- The reviewers had questions about purposes, collaborations, and the novelty of the concepts from both scientific merits and broader impacts.
- The proposal was well written and meritorious but funding available was not sufficient to support many proposals.
- The reviewers have reservations about the risks and proposed activities, and other reasons.

Reviewers' comments are usually very informative. Communicating with the program officer to

solicit additional feedback when possible can provide useful guidance. Discussing the lessons learned with the proposal team is also important, especially if revising and further developing the rejected proposal resulted in establishing good rapport and understanding.

Multiple strategies are possible to turn the rejection into future success. Using reviewers' comments to improve the proposal's quality for the same or similar solicitations can improve chances for funding, especially if a standing panel evaluates the revised proposal. Like the case for a journal article rejection, another strategy is to rewrite parts of the proposal and target another solicitation or program. Resubmitting the identical proposal is generally not recommended because it is unlikely to be responsive to another program. However, consider opportunities to "repackage" some of the ideas, take a subset of ideas, or possibly redevelop and expand some of the ideas. In some cases, you might consider inviting additional expertise to your team to strengthen expertise in some vital areas.

9 Final Thoughts and Recommendations

Each scholar who designed and developed grant ideas has a unique experience with the process. Some enjoy the ride, while many struggle through the process. This article intends to shed light on grant writing myths using experiences and advice from senior scholars who have worked with interdisciplinary teams. To summarize take-away key messages:

- Set aside the necessary amount of time to contribute to the project. Some helpful strategies for doing this could include scheduling an appointment on your digital calendar to avoid interferences. Schedule advising sessions with individual students on one day. Schedule large meetings during lunch.
- Prioritize your work effort consistent with your personal goals. This could include ranking and ordering what it is you need to do.
- Take into consideration your well-being. Align your work activities according to what is expected to result in the largest return on your investment of time.
- Avoid recurrent email and phone checks, setting aside regular times during less productive times of the day to do this. Some researchers report that it is helpful to set aside time to do research two days each week.
- Consistency pays off—keep working on your ideas each week. Minimize the amount of decision making needed for projects. Follow schedules to meet deadlines, and plan for each day's activities.
- Document your progress or work to keep up with tasks. Ask yourself what you need to do when you are not interrupted. Keep a record of thinking and working progress and organize your work materials into folders.
- Do your work and be efficient to elevate skill levels. Remember, it is ok to say no to requests that do not align with your personal/career priorities. Identify if there is sufficient time in your current workload to contribute in a way that would be satisfactory to you and others involved in the collaboration.
- Be patient while building collaboration. It is rewarding and fun to learn about other disciplines.
- Describe your data to the team—what it is, how it works, what you need, and how the data helps with research questions and hypotheses.
- Create productive relationships.
- Use economics to explain how the theories and application would enhance the foundational sciences in other fields (e.g., how the technology works and the expected benefits). While solving societal challenges are our goals, we need to keep it simple to explain economics concepts, models, frameworks, and applications to the interdisciplinary team and focus on the team's overall success.

Finally, what not to do in grant writing? On the team-building side, lacking communication across co-PIs and collaborators, and making assumptions that each team member will complete tasks on time without following through usually leads to visibly patchy proposals that do not suggest a collaborative project. Some step-by-step guidance for team management and creation was discussed earlier with DET and the following sections. On the process management side, not budgeting sufficient time to review and revise the submission gives the reviewers an impression of an unfinished product. Grant reviewers are quick to notice when proposals do not read well or when changes in tenses, nomenclature, and acronyms are present. On the presentation side, not following required proposal development guidelines presented by the funding agency, by, for example, missing the required documents, page limit, and other specific guidelines could result in disappointing rejections without review. Unclear writing and spelling and grammar errors would not lead to the same outcome. Still, they would project an image of the lack of professionalism, which brings into question the ability of a group to do an excellent job with high-quality research and execution to accomplish the science.

This article aims to provide some assistance for agricultural and applied economists to pursue a positive trajectory in the journey of grant writing. The solutions are not one-size-fits-all. Each scholar has unique sets of skills and reasons to apply for grants. Many of us serve multiple roles in our positions as researchers, educators, and service providers. It is a challenging yet exciting to participate or lead interdisciplinary teams. It is an honor and pleasure to introduce and incorporate novel economic theories, concepts, tools, and applications to support problem-solving in a complex systematic environment while pursuing new knowledge and expanding scientific boundaries. All it takes is determination, discipline, and desire to succeed!

About the Authors: Chyi-Lyi Liang is the Kellogg Distinguished Professor and Director of the Center for Environmental Farm Systems at North Carolina Agricultural and Technical State University (Corresponding author: cliang@ncat.edu). Siâ Mooney is Dean of and a Professor in the O'Neill School of Public and Environmental Affairs at Indiana University and IUPUI. Lyubov Kurkalova is a Professor in the Department of Economics at North Carolina Agricultural and Technical State University. D. Keith Roper is a Professor in and Department Head for the Department of Biological Engineering at Utah State University. Leila Hasemi Beni is an Assistant Professor in the Department of Built Environment at North Carolina Agricultural and Technical University.

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Teaching and Educational Methods

Tractable Cubic Cost Functions for Teaching Microeconomics

Scott M. Swinton[a] and Hanzhe Zhang[a]
Michigan State University[a]

JEL Codes: A22, D00, D22
Keywords: Cubic cost function, marginal cost, profit maximization

Abstract
Classes in microeconomics typically use cubic cost functions because they can exhibit marginal costs that fall as output increases to some efficient level, and then rise thereafter. Cubic cost functions embody economies of scale, making it easy to illustrate that concept with quadratic average cost curves. However, designing problems with cubic cost functions is harder than it looks because well-behaved functions must meet several mathematical and economic restrictions. Yet as instructors develop more online assignments and exam questions, they face the need to produce varied problems that support the same learning objectives. This article explains the restrictions needed to generate well-behaved cubic cost functions. It proceeds to show how to generate random parameters for well-behaved cubic cost functions for problems that meet common student learning objectives. An associated workbook contains the algorithms described here.

1 Motivation

How a manager maximizes profit is central to courses in microeconomics and managerial economics. On the output side, this entails understanding unit costs. Unit costs can be analyzed using cost functions, which measure the cost of production as a function of the quantity of products produced (Q). Classic textbook presentations portray a cubic cost function that exhibits marginal costs falling as output increases to some efficient level, and then rising after that. Cubic cost functions embody economies of scale, making it easy to illustrate that concept with quadratic average cost curves.

Many instructors (certainly these two) have discovered that generating cubic cost functions is harder than it looks. A number of standard assumptions used in microeconomic theory constrain the set of parameters that can generate valid cubic cost functions. Davis (2014) presents a set of three similar looking cubic cost functions and explains why only one of them is economically sound. Because finding valid cubic cost functions is tricky, many textbooks offer problems based on quadratic cost functions with linear marginal cost curves—in spite of the conceptual appeal of cubic cost functions (Baye and Prince 2017; Bernheim and Whinston 2014; McGuigan, Moyer, and Harris 2014). If instructors do employ cubic cost functions, they typically identify one or two well-behaved examples and simply tweak the parameters each time they need a new assignment or exam question. Not an ideal system, but it works—so long as one or two well-behaved functions is sufficient.

As communications technology has enabled test takers to share information faster, the need to generate multiple formulations of the same problem has grown. By 2020, cloning cost functions from one or two exemplars ceased to be sufficient. The global shift to online teaching prompted by the COVID-19 pandemic meant that virtually all university economics instructors faced a learning environment familiar to those who have long taught online: students frequently communicate with peers when completing assignments and taking exams. Instructors can respond by varying the problems that different students see. One common approach is for the instructor to build a database of problems that are organized by question type, so that individual problems of the same type may be drawn at random for an online student quiz or examination. Quantitative microeconomic problems that are built from linear or

quadratic functions can be varied with little difficulty while remaining theoretically consistent. But building tractable problems from cubic cost functions is more complicated, because the parameters must satisfy several criteria.

To illustrate the problem, consider the three total cost (TC) functions in Figure 1. Each shows TC as a function of the quantity (Q) of products made. The TC functions arise from three different parameterizations of the cubic function:

$$\text{A: } TC_A(Q) = 3600 + 10Q + 0.5Q^2 + 0.5Q^3$$

$$\text{B: } TC_B(Q) = 3600 + 118Q - 15Q^2 + 0.5Q^3$$

$$\text{C: } TC_C(Q) = 3600 + 177Q - 15Q^2 + 0.5Q^3$$

All three functions have identical parameters for the fixed cost and cubic terms. All have positive costs. But only one suits the purpose of a cost function. TotalCost_A (TC_A) has the most obvious flaw:

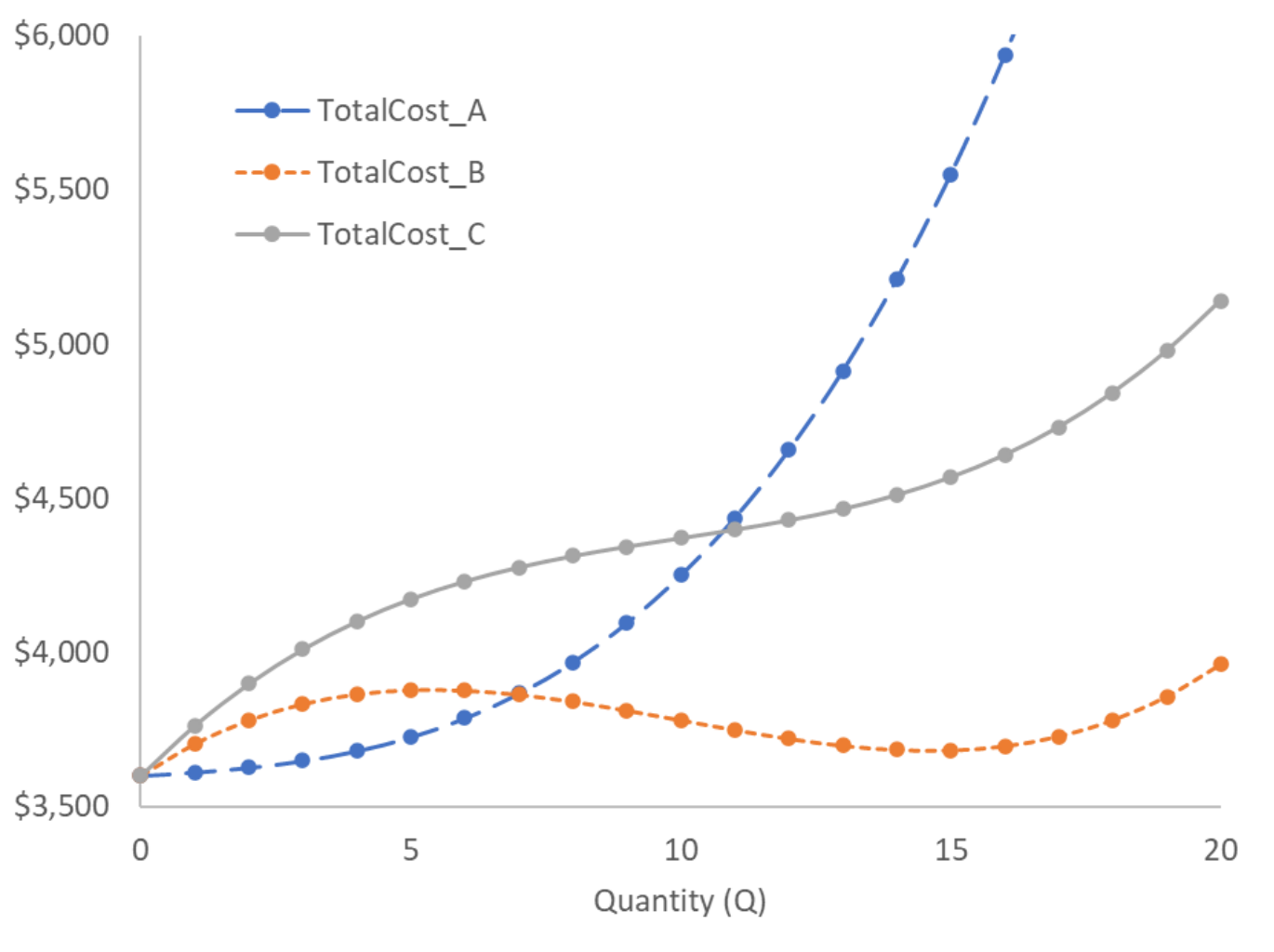

Figure 1. Total Cost Functions with Identical Fixed Cost and Cubic Parameters May Show Pedagogically Undesirable Traits, Like No Minimum Marginal Cost (Curve A) or Declining Total Cost (Curve B)

marginal costs that only increase, making it unable to illustrate the intuition behind economies of scale. Function TotalCost_B (TC_B) has costs that decline between 5 and 15 units of quantity, which is economically nonsensical. TotalCost_C (TC_C) is the only one of the three that has both increasing costs and an inflection point where marginal costs switch from declining to increasing.

The problem of how to generate parameters for tractable cubic cost functions is not new. Davis (2014) offers guidelines for quadratic functions and then presents a somewhat arbitrary set of parameters for cubic cost functions that incorporates the output price. In a more mathematically grounded article, Erfle (2014) derives signs and restrictions for economically consistent parameterization of cubic cost functions. His article is accompanied by a helpful, downloadable spreadsheet where the user can modify cost function parameters and generate updated graphs of the TC, marginal cost (MC), average variable cost (AVC), and average total cost (ATC) functions.

What has changed since those articles appeared is not the economic and mathematical principles shaping well-behaved cubic cost functions, but rather the need to generate multiple problems without difficulty. The objective of this article and the associated workbook is to provide an automated means to generate random cubic cost functions that conform with standard microeconomic cost theory and that students can readily solve.

2 Learning Objectives and Instructor Goals

The broad learning objective for cost analysis is for students of microeconomics and managerial economics to understand how a firm maximizes profit from the output side, via cost functions. (A complementary approach focuses on the input side, via production functions that have a dual, mirror relationship to associated cost functions (Debertin 2012).)

Specific learning objectives of cost function analysis are that (1) the firm's profit is maximized when the marginal revenue (MR) earned from the last unit sold equals its MC in the region where MC is rising, (2) in the short run, the firm's MR must at least cover its AVC, and (3) in the long run, the firm's MR must also cover its ATC. A fourth objective that builds on the first three is that firms may achieve economies of scale when the long-run ATC declines with the scale of output.

For instructors of firm-level cost analysis, the primary teaching objective is to help students to master the four learning objectives above. A secondary, but intimately related, teaching objective is to accomplish this with numerical examples that fully illustrate the concepts. In this instance, "fully illustrate" means using cost functions that can generate sets of results that are consistent with standard microeconomic theory and supporting assumptions.

Cubic cost functions offer the simplest way to illustrate economies of scale via quadratic ATC and MC functions. This article aims to facilitate the teaching of these core ideas by identifying the properties of well-behaved cubic cost functions and applying those properties to generate valid problems. By facilitating the task of generating problems, the algorithm presented here can produce many variations on the same basic problem. It also enables the instructor to identify versions with relatively simple parameters that offer clear solutions.

3 Mathematical Properties of a Well-Behaved Cost Function

Economists use the term "well behaved" as code that means a function meets several criteria for it to make sense economically. For cost functions, those criteria include:

1. All costs are positive, both variable costs (VC) and fixed costs (FC), so $VC(Q) > 0$ and $FC > 0, \ \forall Q$.

2. Total cost is increasing in output quantity: $\frac{dTC}{dQ} > 0$, so $MC(Q) > 0, \forall Q$.

3. The production process exhibits economies of scale up to a point, so ATC declines to a minimum at quantity $Q_{\min}^{ATC}$, after which it increases.

From criteria (2) and (3) follow two consequences:

4. The quadratic MC curve is convex to the origin, so $\frac{d^2TC}{dQ^2} = \frac{dMC}{dQ} > 0$ and $\frac{d^2MC}{dQ^2} > 0$, which formalizes Criterion #3 that ATC reaches a minimum.

5. The minimum MC (which is the inflection point on the cubic TC function) must lie in the region where both $Q > 0$ and $TC > 0$, which ensures that TC is increasing in Q.

These criteria point to a cubic form for cost functions. Combining the specific criteria above with the mathematical properties of cubic polynomials, we can identify limits on the parameters that give shape to the cubic cost function. The cubic formulation here follows the standard economic ordering of terms, starting with the constant, as opposed to the standard mathematical form, which starts with the cubic term.

As in the example above, let the TC function be:

$$TC(Q) = \alpha + \beta Q + \gamma Q^2 + \delta Q^3, \tag{1}$$

where all parameters are assumed to be non-zero. The constant term, α, represents FC:

$$FC = \alpha. \tag{2}$$

VCs are represented by the remaining terms in the TC equation, and AVC is VC/Q:

$$VC(Q) = \beta Q + \gamma Q^2 + \delta Q^3 \tag{3}$$

$$AVC = \beta + \gamma Q + \delta Q^2. \tag{4}$$

MC is the first derivative of TC:

$$\frac{dTC}{dQ} = MC(Q) = \beta + 2\gamma Q + 3\delta Q^2. \tag{5}$$

Overlaying the economic criteria for a well-behaved cubic cost function with the definitions above, we can deduce several parameter restrictions:

1. $\alpha > 0$, from Criterion #1 that all costs are positive and $FC = \alpha$ Eq. (2).

2. $\delta > 0$, from Criterion #2 that TC is increasing in Q and δ is the coefficient on the cubic term, the largest in this polynomial.

3. $\gamma < 0$. This follows from Criterion #5 (and indirectly from Criteria #3 and #4) that the minimum of the MC curve must lie in the positive orthant. Differentiating Eq. (5) and setting the 2nd order condition for the minimum MC = 0 yields $Q_{\min}^{MC} = \frac{-\gamma}{3\delta}$. Since Q > 0 and $\delta > 0$, therefore $\gamma < 0$.

4. $\beta > 0$. This too follows from Criteria #4 and #5 that the MC minimum lies in the positive orthant. To guarantee positive roots for the MC quadratic (meaning no intersection with the Q axis), its discriminant must be negative. Therefore $\gamma^2 - 3\beta\delta < 0$ (Paul 2017), so $\gamma^2 < 3\beta\delta$. Since γ^2 and δ are positive, β must be also.

5. $\gamma^2 < 3\beta\delta$, as noted above, this discriminant condition satisfies Criterion #5 (Paul 2017).

4 Generating Well-Behaved Cubic Cost Functions

The Excel workbook and Mathematica worksheet accompanying this article implement the restrictions above by randomly generating values for α, β, γ, and δ that meet the four sign restrictions above. Then a conditional function checks whether the β parameter meets the fifth restriction, restated to require $\beta > \frac{\gamma^2}{3\delta}$.

Although the five conditions above are all that are necessary to generate cubic cost functions that meet economic criteria, two other conditions are desirable. The first is that the functions should yield problem solutions in whole or simple rational numbers that students can readily interpret. Certain key relationships can guide parameter relationships to generate clean solutions. Three relationships describe the output (Q) levels that minimize the MC, AVC, and ATC curves:

a. $\frac{dAVC}{dQ} = \gamma + 2\delta Q$, so at the AVC minimum: $Q_{\min}^{AVC} = \frac{-\gamma}{2\delta}$.

b. From Eq (5), the MC-minimizing Q, $Q_{\min}^{MC} = \frac{-\gamma}{3\delta}$.

c. $\frac{dATC}{dQ} = -\alpha Q^{-2} + \gamma + 2\delta Q$, so at the ATC minimum, $Q_{\min}^{ATC} = \frac{-\gamma}{2\delta} + \frac{2\alpha\delta}{(Q_{\min}^{ATC})^2} = Q_{\min}^{AVC} + \frac{2\alpha\delta}{(Q_{\min}^{ATC})^2}$, showing how FC and Q cause the ATC-minimizing Q always to exceed the AVC-minimizing Q.

Taking advantage of the fact that $Q_{\min}^{MC}$ occurs at 2/3 of $Q_{\min}^{AVC}$ (Erfle 2014), we can ensure whole-number MC and AVC minima by generating values for $\gamma = -6\delta k$, where k is a randomly drawn, scaling parameter.

The second desirable condition for economic problems is to identify a domain that can generate valid β parameters that do not get excessively large. One parsimonious way to do so is first to generate values for the γ and δ parameters, and then to draw a random β from the k-scaled interval $\left[\frac{\gamma^2}{3\delta}, \frac{k\gamma^2}{3\delta}\right]$, which simplifies to $[12\delta k^2, 12\delta k^3]$ if $\gamma = -6\delta k$. The instructor can choose the interval for random draws on k to suit the scale of interest.

We can generate whole-number ATC values by appropriate choice of the α parameter. The expression for Q_{min}^{ATC} can be rearranged as $\alpha = \gamma(Q_{\min}^{ATC})^2 + 2\delta(Q_{\min}^{ATC})^3$. Employing a reverse engineering approach to find α, we can first select a valid random value for Q_{min}^{ATC}, and then generate the α parameter that will yield this Q_{min}^{ATC}. Recognizing that Q_{min}^{ATC} must exceed Q_{min}^{AVC}, we draw a random integer for Q_{min}^{ATC} from the interval $[(Q_{min}^{AVC} + 1), (2Q_{min}^{AVC})]$. Then plug it into the equation at the beginning of this paragraph.

The workbook and worksheet accompanying this article facilitate generating sets of random parameters that meet the criteria for valid cost functions. They allow the instructor to adjust domains for random parameter draws but offers default domains. For the cubic (δ) parameter, the default domain is [1, 5] in unit increments. For the scaling (k) parameter, the default domain is integers in [2,10], with the minimum value required to satisfy the formula for drawing random values of β. After Q_{min}^{ATC} is drawn, the fixed cost (α) parameter is calculated from the equation above.

To meet the learning objectives identified early in this note, instructors typically wish for students to answer the questions: (1) What is the profit maximizing level of Q?, (2) Should the firm stay in business in the short run?, (3) Should the firm stay in business in the long run?, and (4) How can you tell? To accompany randomly generated cost function parameters, the associated workbook includes a table of derived TC, MC, AVC, and ATC values. It graphs the functions and calculates the whole-numbered Q values that minimize the derived MC and AVC functions. These tools are intended to aid the instructor in constructing workable problems that answer the questions above. However, they can also serve as the basis of teaching examples for courses starting with principles of microeconomics.

To conclude, this teaching resource contribution summarizes the restrictions needed to generate cubic cost functions that are both economically valid and readily solved by students. It further introduces an associated Excel workbook and Mathematica worksheet that generate well-behaved, cubic cost functions with supporting information to assist instructors in building cost analysis problems for courses related to managerial economics and intermediate microeconomics.

About the Authors: Scott M. Swinton is a University Distinguished Professor in the Department of Agricultural, Food, and Resource Economics at Michigan State University (Corresponding author: swintons@msu.edu). Hanzhe Zhang is an Assistant Professor in the Department of Economics at Michigan State University.

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Case Study

The Future of Four Creeks Farm: Scale-Up, Diversify, or Exit?

Olesya M. Savchenko[a], Patrick M. Fleming[b], and Kellie Zambito[a]
University of Florida[a], Franklin & Marshall College[b]

JEL Codes: A22, Q13, Q18
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Abstract
This decision-scenario case study is designed to be suitable for both online and face-to-face instruction in an undergraduate-level agribusiness, agricultural policy, or business strategy course. The case challenges students to assume the role of decision makers for a struggling family-owned dairy farm to determine whether the farm should scale-up, diversify, or exit the industry. Students will (1) learn about the unique features of the U.S. dairy market and domestic government support policies for dairy farms, (2) understand the challenges facing small family-operated farms, (3) apply strategic management tools to analyze and select the best strategic option to ensure short-term and long-term survival of the farm, and (4) advance critical thinking and decision-making skills. This case study is versatile and can be adapted to a variety of classroom settings. It can also facilitate broader discussions of management decisions facing agricultural businesses operating outside of the dairy industry.

1 Introduction

Four Creeks Farm in central Florida is at a crossroads. After more than fifty years in the dairy farming business, the McCall family is struggling to make ends meet. George McCall grew up in the dairy industry and, after thirty years of watching his dad milk cows day in and day out, he decided to keep the farm in the family. Ever since George took over as the CEO and manager of the farm, he and his three children—Steven, Jessica, and Adam—have been working hard to grow the family business. However, low milk prices, industry consolidation, and steady milk supply against a backdrop of declining consumer demand for fluid milk makes it a tough market in which to operate (MacDonald, Cessna, and Mosheim 2016). Like many other small U.S. dairy farmers, the McCalls are contemplating whether it is financially sustainable to stay in the dairy industry by scaling up or diversifying operations to include alternative sources of revenue, or whether they should exit the industry.

Steven, Jessica, and Adam look forward to the day they too can raise their children on the working farm. Exiting the dairy market is not an option they want to consider, so they have spent weeks formulating their plan to save the family farm. Steven McCall believes the answer to their faltering finances is to market their milk as free-range or organic. Jessica McCall is eager to diversify by integrating an agritourism segment to the farm that would include a gift shop, ice cream parlor, and a small restaurant or café. Adam, the economist of the family, believes the only way to be profitable is to scale up milk production, which will lower costs due to economies of scale. To weigh these options the siblings will use the Political, Economic, Social, Technological, Environmental, and Legal (PESTEL) framework to analyze the dynamics of the dairy industry that can influence current and future performance of the farm. PESTEL analysis is a commonly used tool that helps managers of agricultural businesses identify various factors from the external environment that may influence performance. To further inform the family's decision, the siblings plan to compare the estimated costs and capital investments necessary to pursue each option, along with nonfinancial considerations.

The market continues to steadily decline, and George McCall faces a challenging decision: should he sell the farm? Or should he market his product differently, build an agritourism facility, or scale up his operation? The family is eager to make a change and avoid locking their gates for the last time. As Mr. McCall sits in his home office, he anxiously chews on a toothpick wondering what move he should make.

2 The U.S. Dairy Industry and the Fluid Milk Market

The dairy industry is an integral part of the agricultural portfolio in the United States. American consumers view dairy products as an essential food item and an important part of a household's weekly shopping basket. However, the U.S. dairy industry has been undergoing a significant structural transformation characterized by farm consolidation, exit of small dairy farms, and a shift of milk production to large operations (Figure 1). Despite a 50 percent increase in the total milk production in the United States, the number of dairy farms has decreased by more than 75 percent in the past three decades (MacDonald, Law, and Mosheim 2020). Larger commercial dairies are absorbing the smaller family-owned dairy farms, or indirectly pushing them out of business through a steady milk supply, one of the factors keeping milk prices low.

The success of the dairy industry depends on economies of scale, technological advances, and a reliable supply of key inputs (Savaskan 2019). Larger dairies can earn substantially higher net returns for the milk they produce when the unit cost of production falls with increased herd size. For example, the unit costs incurred by large farms with herd sizes of 2,000 or more cows can be as much as 24 percent lower than farms with herd sizes between 500 and 999 cows (MacDonald et al. 2016). Despite the competition, some small dairies remain profitable by investing in various value-added activities such as expanding their operations to include agritourism, seeking higher milk prices through organic milk, selling other dairy products in-house such as cheese or ice cream, or breeding high-quality heifers and calves for sale (MacDonald et al. 2020).

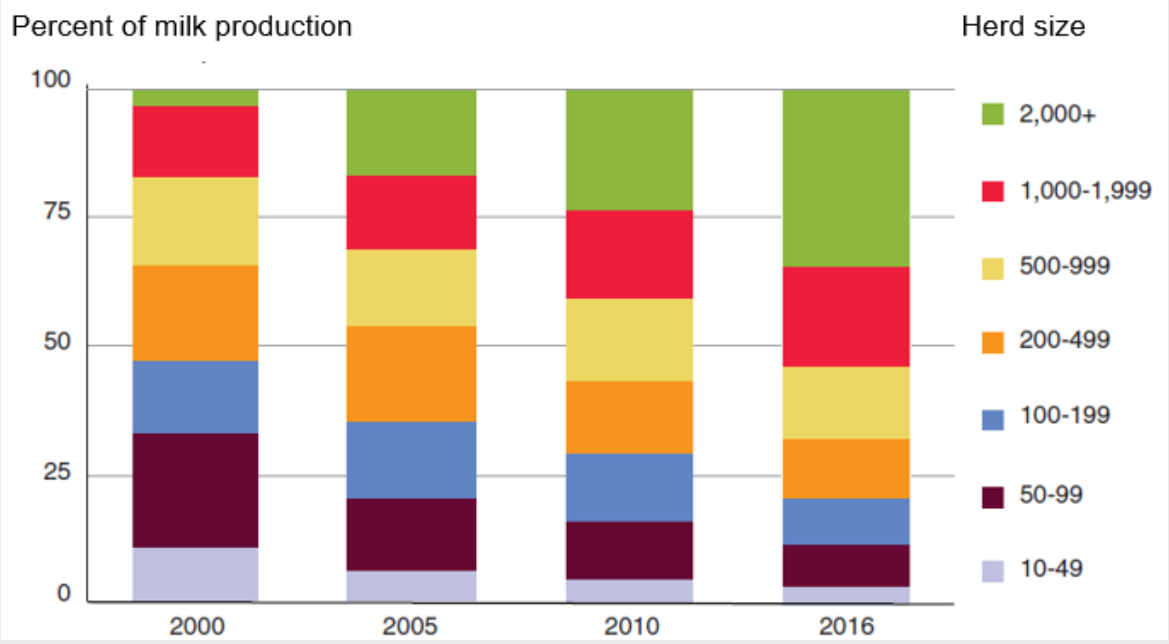

Figure 1. Shift in Milk Production to Larger Farms

Source: Figure taken from MacDonald, J.M., J. Law, and R. Mosheim. 2020. *Consolidation in US Dairy Farming.* Washington DC: U.S. Department of Agriculture, Economic Research Service, ERR 274.

Competition within the industry is based mostly on price and cost-minimization since conventional (non-organic) milk is homogenous throughout the market (Savaskan 2019). Over time, milk production per cow has risen with improvements in genetics, nutrition programs, and new technologies such as cow activity monitors and automated milking systems (Barkema et al. 2015). Milk production continues to steadily increase even as the number of farms and demand for fluid milk is decreasing. Since 2000, dairy milk consumption has fallen by 25.8 percent for the average American (Figure 2). Other segments of the dairy industry (e.g., butter, cheese, and ice cream) and the plant-based milk (non-dairy) industry are outpacing the fluid milk (dairy) market in terms of growth, as consumers continue to shift their preferences away from fluid milk. Non-dairy alternative milk beverages now account for 14 percent of revenue in the retail milk sector (The Good Food Institute 2020). The most popular milk alternatives include almond, soy, oat, coconut, and rice milk.

Decreasing demand coupled with a steady aggregate supply have contributed to low prices of milk. Dairy farm gross income comes primarily from milk sales, while feed represents a large portion of total costs. Prices of both milk and feed fluctuate widely based on factors outside of farmers' control, exposing dairy farmers to high financial risks. Milk price volatility is attributed to unique features of a dairy market that is characterized by inelastic supply and demand that responds weakly to changes in prices (MacDonald et al. 2016). Labor is another substantial component of total costs. Because of increasing labor costs over time and difficulty finding reliable local employment, many large dairy farms depend heavily on immigrant or undocumented labor to complete daily milking tasks (Simnitt and Farnsworth 2016).

The industry is also under increasing pressure from consumers and environmental groups to reduce its negative environmental impacts (Olynk 2012). Dairy operations contribute significantly to climate change and water pollution (Lötjönen, Temmes, and Ollikainen 2020). Methane, a potent greenhouse gas, is released from decomposing manure and from the digestive tract of ruminant animals like cows. Manure spills and runoff contaminate groundwater and surface water, contributing to algae blooms and oxygen-deprived dead zones (Bailey et al. 2020; Lötjönen et al. 2020). These environmental impacts are exacerbated with increasing commercialization of dairy operations that concentrate thousands of cows in a single barn or lot.

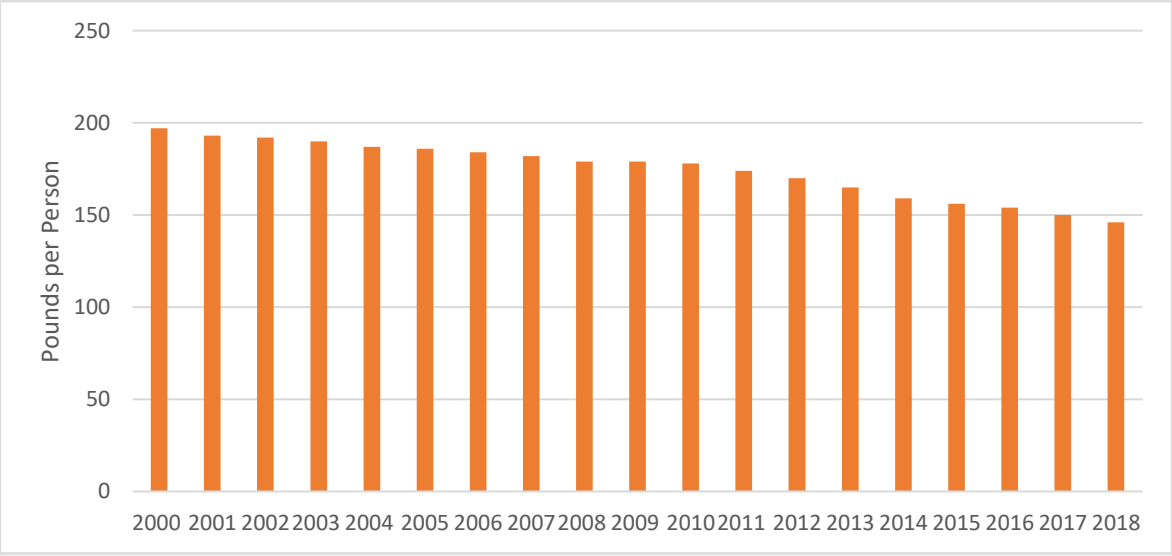

Figure 2. U.S. Per Capita Consumption of Dairy Milk

Source: U.S. Department of Agriculture, Economic Research Service. 2020. *Dairy Data.* Washington DC: U.S. Department of Agriculture, Economic Research Service. Retrieved from https://www.ers.usda.gov/data-products/dairy-data/.

3 Government Support Policies and Regulations

The U.S. government is heavily involved in the dairy market through a variety of policies and programs primarily focused on mitigating the effects of price volatility and financial risk. Over time, dairy support policies have evolved from setting price floors for milk products to creating programs that soften the effects of low prices, particularly in times of large decreases in the price of milk relative to feed (MacDonald et al. 2016).

Created in the 1930s, Federal Milk Marketing Orders[1] (FMMOs) provide guidelines governing the purchase of fluid milk, including a minimum price, from farmers supplying milk in a specified geographical marketing area (U.S. Department of Agriculture, Agricultural Marketing Service 2021a).[2] Minimum prices are determined monthly and move directly with market prices of dairy products. These prices are based on the class in which the milk product falls. Fluid milk is in Class I, for which prices remain volatile due to changes in consumers' tastes that lead to demand fluctuations and changes in feed prices (MacDonald et al. 2016). Class I minimum FMMO price of milk at $17.78 per hundredweight in 2020 is expected to decrease to $16.92 per hundredweight by the year 2025 (Agricultural Markets and Policy 2021). For the McCall family such a price decrease implies a change in annual net returns—the difference between gross income and the total cost of milk production—from a profit of $0.71 per hundredweight to a loss of $0.15 per hundredweight.[3]

In 2014, Congress established the Margin Protection Program for Dairy (MPP), which was revised and renamed as Dairy Margin Coverage (DMC) in 2018. The DMC is a voluntary program that offers payments to enrolled farmers when the difference between average milk prices and feed costs falls below a certain dollar level. The 2018 revisions to the DMC program included a greater focus on supporting small dairy farms by allowing them to pay lower premiums for margin coverage. The payouts under the DMC program totaled $150 million in 2018 and $279 million in 2019 (MacDonald et al. 2020). The Livestock Gross Margin (LGM-Dairy) and the Dairy Revenue Protection (Dairy-RP) programs are aimed at protecting farmers against drops in the milk-feed margin and unexpected losses in quarterly revenues from sales of milk compared to a guaranteed coverage level (MacDonald et al. 2020). Despite substantial federal spending to support dairy farmers, these programs are not designed to assure profitability for all dairy farms. These policies may slow down the trend of small farm closures, but they do not address the broader issues facing the industry such as milk oversupply, continued farm consolidation, and the cost advantages of larger operations in comparison to smaller farms.

The U.S. government also uses trade agreements to expand the U.S. dairy export market, such as the United States-Mexico-Canada Agreement (USMCA) that replaced the North American Free Trade Agreement (NAFTA) in 2020. USMCA will maintain NAFTA's duty-free access to Mexico's dairy market, which is the largest market for U.S. dairy exports (Greene 2019), but will also expand access to the Canadian dairy market. Exports from the United States to Canada have been capped at about 3 percent of Canadian total dairy sales under the tariff-rate quota (TRQs) imposed by Canada (Noll and Litan 2018) that limited exports beyond this amount through high tariffs. Under the USMCA, Canada will allow the United States to export 3.59 percent of the Canadian dairy market tariff-free before the high tariffs kick in. In addition, Canada will expand the quota by an additional 50,000 metric tons (110 million pounds) for fluid milk by 2026 and will keep increasing the quota by 1 percent every year for thirteen years

[1] For more information on FMMOs see Greene, J. 2017. *Federal Milk Marketing Orders: An Overview*. Washington DC: Congressional Research Service, CRS Report R45044. https://crsreports.congress.gov/product/pdf/R/R4504.

[2] A marketing area is typically defined as a geographic area in which processors of dairy products (or "handlers") compete for milk sales (U.S. Department of Agriculture, Agricultural Marketing Service 2021a).

[3] These calculations are based on feed and operation costs provided in Table 1. The dairy industry frequently expresses income and costs per one-hundred pounds or hundredweight of milk produced.

thereafter[4] (van Kooten 2020). The United States International Trade Commission projects that the USMCA will lead to an increase of $314 million per year of U.S. dairy exports to Mexico and Canada (Shikher et al. 2019). Despite these positive projections, the expanded access to the Canadian dairy market will have a negligible impact on the U.S. dairy industry overall (Golub et al. 2020), including on smaller operations like Four Creeks Farm that do not directly export dairy products.

In addition to the support programs and trade policies, the U.S. dairy industry is regulated at the state and federal levels through laws pertaining to food safety and environmental protection. Dairy farms are required to obtain a license from state government before they can begin operating. State departments, such as the Florida Department of Agriculture and Consumer Services, regularly inspect dairy facilities and work with the U.S. Food and Drug Administration to ensure safety of dairy products. Dairy farms are also required to meet federal and state environmental regulations. The Clean Water Act (CWA) requires states to control point sources of water pollution, such as wastewater treatment plants, but this excludes most agricultural runoff, which is considered to be a nonpoint source. However, livestock farms classified as Concentrated Animal Feeding Operations[5] (CAFOs) are subject to the CWA National Pollutant Discharge Elimination System (NPEDS) permitting requirements. NPDES permits are required if a CAFO discharges pollutants to any waters of the United States (U.S. Environmental Protection Agency n.d.). Further, individual states have developed water quality goals with various funding programs available to incentivize farmers to implement best management practices that reduce the amount of animal waste, fertilizers, and other contaminants entering water bodies.

4 Dairy Supply Chain: From Farm to Table

Across the United States, there are several breeds of dairy cattle. The most common breed is the Holstein. Holstein cattle are very efficient producers of low-fat content milk, primarily processed for fluid dairy products (Dairy Dealer n.d.). The dairy supply chain (farmers, wholesalers, distributors, retailers, consumers) is complex, yet efficient (Figure 3). The supply chain starts in the milking parlor where milk is transported in pipes and stored in refrigerated tanks. Cows are milked two to three times daily. Because milk is highly perishable, it needs to be cooled quickly and transported soon after it is produced. Refrigerated tanker trucks pick up the milk from a farm and transport it to a processing facility where the milk is homogenized, pasteurized, packaged, and shipped to grocers. Milk makes its way from the cow to the grocery store shelf within a two-day timeframe (Kroll 2015). Milk typically comes from dairy farms within 300 miles from a grocery store as transporting fluid milk over longer distances is costly and impractical. Most international trade in milk occurs through nonfat powdered milk.

The U.S. milk industry primarily consists of farmers who are members of milk cooperatives that transport, process, distribute, and market their products. Cooperatives allow farmers to pay a certain amount of money for a guaranteed milk market and a commitment for the greatest possible return (Novakovic and Wolf 2018). Milk cooperatives, which began as local or regional associations in the early twentieth century, now primarily include multi-billion dollar businesses, each with hundreds or thousands of farmer-members, such as Dairy Farmers of America, California Dairies, Inc., and Land O' Lakes, Inc. Cooperatives and individual producers alike sell their products in compliance with FMMOs.

[4] Other dairy products will be granted the following additional quota: cheese (12,500t), cream (10,500t), SMP (7,500t), butter and cream powder (4,500t), yogurt and buttermilk (4,135t), concentrated and condensed milk (1,380t), and other dairy products (4,660t; van Kooten 2020).

[5] A dairy farm is classified as a CAFO if it confines at least 700 or more mature cows at a single site or facility. Smaller operations may also be considered CAFOs under certain conditions (University of Illinois Extension n.d.).

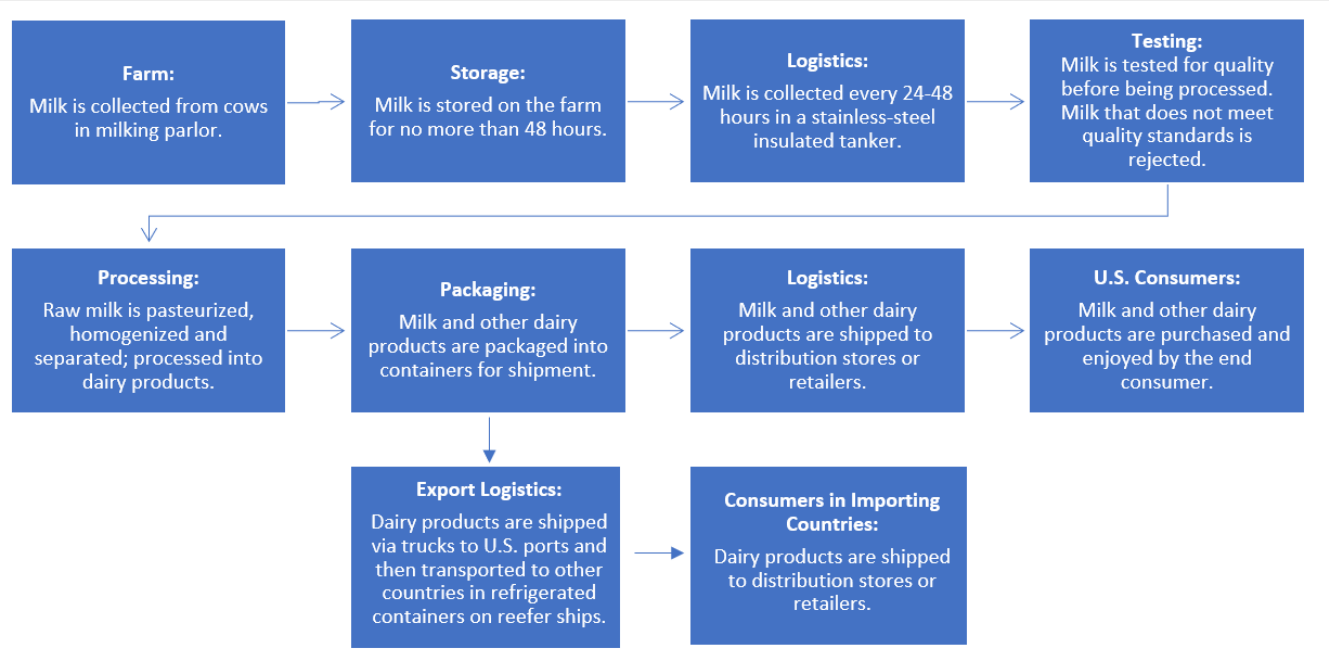

Figure 3. Dairy Industry Supply Chain

5 The Dairy Industry in Florida and The Four Creeks Farm

Florida is one of the leading U.S. dairy states. In 2020, the dairy industry in Florida included 114,000 cows, mostly Holstein, in herds ranging from 150 to 5,000 head. That year, Florida milk production reached 2,343 million pounds (Agricultural Markets and Policy 2021). Most of Florida's dairy cows are concentrated in two counties: Lafayette and Okeechobee. Many Florida dairy farmers, including George McCall of Four Creeks Farm, are producer-members of the Southeast Milk, Inc. dairy cooperative. Southeast Milk sends a truck to pick up milk from Four Creeks Farm every day and transports it to a processing facility before the milk makes its way to the consumer (Figure 3).

Four Creeks Farm was founded in 1948, when George McCall's father, Frank, purchased 2,200 acres of land north of Tampa, Florida, most of which is now used for grazing. Located centrally on the land is the family's milking parlor, where 625 cows are milked twice a day, producing about 18,000 pounds of milk per cow annually. The dairy's basic finances are outlined in the first column of Table 1. Four Creeks Farm supplies milk products to the southeastern United States, primarily in central Florida, through FMMO 6.

6 The Road Ahead

Steven, Jessica, and Adam would like to ensure a strong financial future for the farm, but they have not been able to agree on a single strategy the farm needs to pursue going forward. None of them want to see their family's farm join the ranks of small dairies that have gone out of business over the past half-century. They are considering diversifying the farm operations in different ways—either through marketing their milk outside conventional supply chains, adding an agritourism aspect to the business, or scaling up to reduce their unit costs of production. However, seeing trends in the industry, their father George McCall believes his children should carefully consider selling the herd and leaving dairy altogether.

6.1 Diversification of Farm Operations: Beyond Conventional Supply Chains

The silver lining of dairy production in sunny Florida is that the dairy cattle have access to grasslands

Table 1. Four Creeks Farm Costs and Returns per Hundredweight (cwt), 2016

	Current Herd Size 625	Projected Herd Size 1,000-1,999	Projected Herd Size >1,999
Gross Returns	18.93	19.05	18.90
Milk Sales	16.93	16.93	16.93
Other Returns	2.00	2.12	1.97
Operating Costs			
Total Feed Costs	8.71	8.97	9.20
Purchased	4.51	7.18	7.61
Homegrown	4.15	1.78	1.59
Grazed	0.05	0.01	0.00
Other Operating Costs	2.94	2.71	2.32
Total Operating Costs	11.65	11.68	11.52
Allocated Overhead			
Hired Labor	2.18	2.30	1.75
Unpaid Labor	0.69	0.30	0.10
Capital Recovery	3.85	3.60	3.37
Other Overhead Costs	0.70	0.66	0.41
Total Costs	19.07	18.54	17.15
Net Returns	**-0.14**	**0.51**	**1.75**

Note: Adapted from MacDonald, J.M., J. Law, and R. Mosheim. 2020. *Consolidation in US Dairy Farming*. Washington DC: U.S. Department of Agriculture, Economic Research Service, EER 274. Capital recovery costs are calculated as annualized replacement value of the capital.

every day of the year. This situation reduces feed costs for the farmer and provides a potential marketing opportunity for free-range cattle. Steven McCall learned about a new marketing concept from a dairyman in south Florida, who has started a program called "Free Range 365.[6]" Cattle who graze pastures every day naturally produce milk with health attributes that set the product apart from conventionally produced milk. Free-range cows produce milk that is higher in Omega 3 and Conjugated Linoleic Acids (CLAs), thus providing more health benefits with anti-carcinogenic and anti-inflammatory properties (Viladomiu, Hontecillas, and Bassaganya-Riera 2016). The Free Range certification promises consumers that cattle have access to grass 365 days a year. In contrast, the organic milk certification requires cattle to graze during a grazing season of approximately 120 days. Interestingly, outside of the grazing season, grass-fed cows are fed forage-based feeds such as haylage, but may not necessarily be grazing on grasslands (Free Range 365 n.d.). Free-range products could bring a 25- to 50-cent premium per hundredweight to a farmer. Alternatively, the price premium for organic milk doubles what producers can charge per hundredweight (MacDonald et al. 2020).

Steven McCall believes that free-range milk will excite consumers seeking a premium dairy beverage. If the free-range milk is sold in stores for approximately $3.50 per half gallon, the investment will bring an additional $2.92 per hundredweight to the McCall's dairy operation. A major challenge that comes with selling free-range milk is that the dairy, or a collective of dairies, must produce enough milk to fill an entire milk processing plant daily for the milk to be marketed as purely free-range. There is a very small presence of free-range milk on the market in Florida, with only four dairies in the state being Free Range 365 certified; so there is potential to penetrate the market on a larger scale if a collective of dairies can join together to fill a milk processing plant with free-range milk on a daily basis.

[6] The primary requirements a dairy farm needs to meet to obtain Free Range 365 certification include unrestricted access of lactating animals to pasture 365 days per year and availability of fresh water in each paddock. For more details, see https://www.freerange365.org/qualifications.

Another option Steven McCall believes could be a viable solution is to sell organic milk. With numerous other Florida dairy farms already producing organic milk, the McCall family would have access to a dairy processing plant that is already processing exclusively organic products. This would allow for improved marketing opportunities and a milk price premium without the need to spearhead the production of a new processing plant for free-range milk.

Of course, transitioning to organic milk production presents its own challenges. Farmers producing organic milk must follow the rules outlined under the National Organic Program (NOP) that requires a farm to obtain certification through an accredited USDA certifying agency. There is a three-year transition period where the McCall family must operate as a 100 percent organic farm by not using any prohibited inputs (e.g., GMO seeds, synthetic pesticides, and synthetic fertilizers) before their milk can be labeled as organic (U.S. Department of Agriculture, Agricultural Marketing Service 2021b). In addition, the dairy cows also must meet certain qualifications, such as eating certified organic feed and meeting at least 30 percent of their dietary needs from pasture. The transition to organic certification is easier for cattle who already obtain a large portion of their forage from pasture, rather than nonorganic forages such as corn silage. During the three-year transition period, the McCall family will incur all the costs associated with organic milk production without receiving the organic premium on their milk. For example, the total organic feed cost is about $5.60 more per hundredweight than conventional feed cost (MacDonald et al. 2020).

6.2 Diversification of Farm Operations: Agritourism

Jessica McCall, passionate about agricultural advocacy, also worked in the food service industry for eight years after earning a degree in culinary arts. She is urging her family to invest in an agritourism facility on the farm property. Jessica sees the opportunity to organize field trips for local schools and tourists to learn about the farm via wagon rides through the pastures and touring of the milking barns. Additionally, she envisions the facility will encompass a dairy product processing plant which will allow the family to sell local milk, cheese, butter, and ice cream in a small farm restaurant or café along with other farm merchandise. This option will be costly to start up, and likely will require obtaining a loan for the investment. The startup cost of building the facility equipped for milk processing and for agritourism will be approximately $850,000. Jessica will use her experience in culinary arts and her experiences with local small businesses to manage dairy product production and packaging, agritourism marketing, and finances. She will also manage a team of 8 employees. Two will be hired to work as front of house waitstaff and cashiers, and 2 others will focus on making cheese and ice cream. They would be paid between $20 and $25 per hour. The other 4 employees will be part-time staff who she hires through local high school agricultural groups, like FFA and 4-H, to lead tours and gain unpaid internship experience in the dairy industry. Both Steven and Adam will also help manage the agritourism business full-time if the family decides to pursue this option. The projected revenue of this farm enhancement project is approximately $600,000 annually.

Four Creeks Farm is located on the outskirts of Hillsborough County and just 30 miles outside of Tampa, an established tourism hot spot. Being near a large city will help make the farm a popular destination for tourists and residents alike. Additionally, Hillsborough County has 250 public and 162 private schools and many summer camps within proximity to the dairy. Jessica plans to market farm tours to schools for field trips allowing students at all grade levels an opportunity to learn about dairy cattle and milk production. Additional costs will be accrued as the agritourism operation grows, such as purchasing wagons to transport groups, and additional staff. However, Jessica believes there is room to grow, as the farm will draw customers from schools, out-of-state tourists, as well as the local community who will be excited to pay a price premium for locally produced and processed dairy products in the farm store.

6.3 Scaling Up Farm Operations

Adam McCall, who has earned a degree in economics, insists that the best way the McCall farm can be profitable is by increasing the herd size (scaling up) to achieve economies of scale. Larger farms have lower costs and higher returns because they can use both labor and capital more intensively (MacDonald et al. 2020). Like many other family-owned farms, Four Creeks Farm uses unpaid family labor,[7] but as farms grow, they rely much more heavily on hired labor. To achieve this goal, the McCall family will have to hire more workers to milk more cows three times a day, but it will also result in production of more milk per hour of labor. To increase its herd size, the McCall family will need to purchase more Holstein cows, that cost between $1,000 and $2,000 per cow (Dairy Dealer n.d.). The farm's milking parlor current capacity supports up to 1,000 cows, but it will require additional capital investments in equipment and expansion to milk more cows. It costs $24,000–$32,000 per milking stall for a new parlor and $3,000–$6,000 per milking stall to retrofit an existing parlor (Kammel 2015). A double 16 milking parlor with 32 milking stalls would be necessary to milk 1,000 cows assuming the parlor operates 21 hours a day and cows are milked 3 times a day. While these capital investments are expensive, Adam argues that as the farm becomes larger, it will realize lower capital recovery costs on capital such as barns for the herd and storage of feed and milking equipment (MacDonald et al. 2020). The farm may also need to invest in a computerized feed system to achieve higher milk yield and manage feed costs more efficiently.

The family has enough land to support a dairy with 2,000 cows without the need to purchase additional land. As the herd size increases, cows graze in pastures less, eat a higher share of purchased feed, and spend more time in barns and lots (MacDonald et al. 2020). Adam estimated the returns and costs for different herd sizes and plans to use these estimates to persuade the rest of the family to scale up (see Table 1). It is clear to him that the economic logic implies the family farm should get bigger if they want to stay in the dairy industry in the twenty-first century.

6.4 Exiting the Dairy Industry

The McCalls prefer not to think about the possibility of selling their family farm, but they understand that this option needs to be evaluated as well. Farmland prices range between $3,000 and $13,500 per acre in Florida. George McCall estimates that the family can sell the farm for $11,000 per acre. This would include their five-bedroom house, milking parlor, barn, and other equipment present on the farm. They can also sell their cows for $1,145 per head. However, there is much more to this option than the financial considerations alone. Selling the farm means that the family will give up on their dream of continuing the family business, abandoning a lifestyle and profession they love. They consider a farm environment to be an attractive place to raise children, and the family places a high value on preserving options and building opportunities for future generations.

To determine whether the McCall family should diversify, scale up, or exit the dairy industry, the siblings plan to conduct a comprehensive analysis of the industry and their own farm operations, as well as weigh the pros and cons of pursuing each option based on their overall goals. They will use the PESTEL analysis to understand the current industry conditions and future trends. This analysis will help them identify industry-wide factors that pose risks to the farm's viability and those that present potentially profitable opportunities. The siblings will also evaluate the strengths and weaknesses of the farm operations to understand whether the farm is positioned well to take advantage of the specific options that are proposed. They further intend to compare the estimated costs and capital investments required to realistically pursue each option. Finally, the siblings will incorporate nonfinancial considerations in their decision-making process, such as the importance of continuing the dairy operation for the McCall family and the cultural role that small-scale family-owned dairy farms play in U.S. agriculture and society.

[7] The cost of unpaid labor is the opportunity cost of not working elsewhere.

7 Discussion Questions

This case study is versatile and can be adapted to a variety of classroom settings. Instructors have the flexibility to focus on a range of issues and concepts presented in the case, from learning about the U.S. dairy industry to the application of strategic management tools and quantitative analysis.[8]

7.1 Part I: Introducing the Decision Scenario and the Case Study Method

Prior to assigning this case study, instructors should review the case study method with students. Instructors should start discussion by highlighting that the challenges the McCall family is facing are representative of many family-owned dairy and nondairy farms in the United States and worldwide. It is important to point out to students that in addition to the business-focused analysis of the different options for Four Creeks Farm's future, they should also consider the nonfinancial reasons for why the McCall family may want to keep the farm and, more broadly, why having smaller- to medium-sized farms in the U.S. dairy industry could be valuable.

7.2 Part II: Understanding the Industry

1. What are some of the characteristics and trends of the U.S. dairy industry that impact the Four Creeks Farm? To answer this question, analyze the U.S. dairy industry following the PESTEL framework.

		List the Characteristics and Trends of the U.S. Dairy Industry That Impact the Farm
P	**POLITICAL:** What government actions influence the industry and impact the farm's decisions?	
E	**ECONOMIC:** What macroeconomic factors impact the farm (e.g. price stability, levels of employment, aggregate demand, etc.)?	
S	**SOCIOCULTURAL:** What societal actions, norms, and values have implications for the farm?	
T	**TECHNOLOGICAL:** What technological advancements and innovations within the industry impact the farm and its competitiveness?	
E	**ECOLOGICAL:** What relevant environmental issues impact the industry and the farm?	
L	**LEGAL:** What regulations and laws have a bearing on the farm's operations and profitability?	

[8] Based on the experience of the authors, who have used this case study in their classrooms, students can be easily engaged in discussion of this case. Student feedback suggests that many are unaware of the challenges facing the U.S. dairy industry, how the industry is organized, or the extent of government intervention in the U.S. dairy market.

2. Which of the industry factors you identified threaten Four Creeks Farm's operations and profitability? Why?
3. Which of the external industry factors you identified represent opportunities for Four Creeks Farm that are likely to contribute to the farm's profitability? Why?
4. How is the U.S. dairy industry likely to evolve over time?
5. Should the government continue to intervene in the dairy market and provide support policies for the dairy industry? Why or why not?
6. Do you think there should be any changes in how the government supports the dairy industry? If so, how should policy be changed (e.g., price floors, supply or quantity restrictions on milk production, greater income support)?
7. How do current U.S. trade policies (e.g. tariffs) and the country's relationship with other nations affect the Four Creeks Farm?

7.3 Part III: Analyzing the Farm Situation

8. What internal strengths does the Four Creeks Farm have that can contribute to the farm's success and profitability in the future?
9. What internal weaknesses does the Four Creeks Farm have that can hinder the farm's successful operation?
10. What factors other than profit motivate the McCall family to continue the operation? Do you believe these motivations to continue the family business conflict with or complement the profit motive?
11. Collect arguments for and against pursuing each of the options that the McCall children proposed to save the farm. Make sure to support your arguments with both qualitative and quantitative analysis of each option.

7.4 Part IV: Making a Decision

12. Are these options mutually exclusive? Are these options financially viable? Could more than one option be realistically pursued at the same time? Which ones?
13. Is there another, potentially better, option that the farm could pursue that is not provided in the case?
14. Assume the role of the decision maker for the McCall family. What should the McCall family do to ensure the future survival and profitability of the Four Creeks Farm?
15. How should the McCall family proceed with the implementation of the action plan you recommend?

About the Authors: Olesya M. Savchenko is an Assistant Professor in the Food and Resource Economics Department at the University of Florida (Corresponding author: olesya.savchenko@ufl.edu). Patrick M. Fleming is an Assistant Professor in the Department of Economics at Franklin & Marshall College. Kellie Zambito is a Graduate Student in the Food and Resource Economics Department at the University of Florida.

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Case Study

Market Power in the Fluid Milk Industry in the Eastern United States

Yuliya V. Bolotova
Clemson University

JEL Codes: L1, L2, L4, L66, Q13
Keywords: Antitrust, Capper-Volstead Act, cooperatives, fluid milk industry, Federal Milk Marketing Orders, margins, oligopoly, oligopsony, price-fixing, Sherman Act

Abstract
The motivations for this case study are recent developments in the fluid milk industry in the Eastern United States. These developments reflect the effects of increasing consolidation and concentration as well as emerging competition issues related to the buyer and seller market power of fluid milk processors. Using a marketing margin framework, this case study provides simple contemporary applications of the economic models of the profit-maximizing behavior of firms possessing buyer and seller market power in the fluid milk processing industry. The case study illustrates a marketing margin analysis, as applied to the fluid milk supply chain, including a basic empirical market and price analysis. The intended audiences are undergraduate and graduate students as well as extension and outreach audiences. The case study includes a teaching note with a set of discussion questions and suggested answers. In addition, the teaching note discusses teaching objectives, teaching strategies, and student background knowledge.

1 Introduction

The motivations for this case study are developments in the fluid milk industry in the Eastern United States in recent decades. These industry developments reflect the effects of increasing consolidation and concentration (structural changes) in the fluid milk supply chain, emerging competition issues related to the buyer and seller market power of fluid milk processors, and the market power effects on dairy farmers and final consumers. Using a marketing margin framework, this case study provides simple contemporary applications of the economic models of the profit-maximizing behavior of firms possessing buyer and seller market power in the fluid milk processing industry. In addition, the case study illustrates a marketing margin analysis, as applied to the fluid milk supply chain.

The fluid milk supply chain in the United States has been affected by increasing consolidation and concentration, including a series of mergers and acquisitions involving dairy cooperatives and fluid milk processors (Shields 2010). Dairy Farmers of America (DFA), the largest dairy cooperative in the country, was formed in 1998 as a result of the merger of four large regional dairy cooperatives. Dairy cooperatives have historically been involved in handling (including processing) and marketing of their farmer-members' milk and in representing dairy farmers in contract negotiations with milk processors. In 2001, Suiza Foods Corporation, then the largest fluid milk processor in the country, acquired Dean Foods Company to form a new company named Dean Foods (Dean), which became the largest fluid milk processor in the country.

In 2007 and 2009, dairy farmers (plaintiffs) in the U.S. Southeast and Northeast regions filed class action antitrust lawsuits, in which they alleged that Dean and DFA (among other defendants: fluid milk processors and milk marketing agencies) engaged in anticompetitive conduct, which restricted competition in fluid milk markets in these regions (Shields 2010; Greene and Rhee 2011; Abrams, Commins, and Foix 2014). This conduct affected the sale, purchase, marketing, and processing of Grade A milk used in fluid milk manufacturing (Class I milk) in Federal Milk Marketing Orders 5 (Appalachian), 7

(Southeast), and 1 (Northeast). Dairy farmers claimed that DFA and Dean agreed to not compete for Grade A milk used in fluid milk manufacturing and that they limited dairy farmers' access to fluid milk processing plants, which taken together substantially restricted marketing options for dairy farmers and decreased milk prices paid to dairy farmers. In summary, the lawsuits alleged a conspiracy among the defendants to restrain trade in fluid milk markets and to fix milk prices as well as a conspiracy to monopolize and monopsonize fluid milk markets in the Southeast and Northeast regions, which violated sections 1 and 2 of the Sherman Antitrust Act (1890).[1]

After several years of litigations, the lawsuits were settled. Dean and DFA agreed to pay substantial monetary penalties, and DFA agreed to change some of its business practices. Neither Dean nor DFA admitted to any wrongdoing. The payments from DFA and Dean to dairy farmers in the Southeast region totaled $158.6 million and $140 million, respectively (Foix 2013; Kick 2013; Walker 2013).[2] The payments from DFA and Dean to dairy farmers in the Northeast region totaled $50 million and $30 million, respectively (Webster 2015; Fatka 2018; Natzke 2018). The DFA's settlement agreements included changes in some of DFA's business practices, which intended to restore competition in fluid milk markets in the Southeast and Northeast regions.[3] Table 1 presents a timeline of the events relevant to these milk antitrust litigations.

This case study aims to help students understand the effects of structural changes and competition issues in the U.S. fluid milk industry—changes and issues that increase in importance in light

Table 1. U.S. Southeast and Northeast Milk Antitrust Litigations: A Timeline of Relevant Events

Date	Action
2001	Suiza Foods Corporation acquired Dean Foods Company. A new company was named Dean Foods.
2001	Anticompetitive conduct of DFA and Dean began in the Southeast region (FO5 "Appalachian" and FO7 "Southeast").
2002	Anticompetitive conduct of DFA and Dean began in the Northeast region (FO1 "Northeast").
2007-2008	Dairy farmers in the Southeast region filed class action antitrust lawsuits.
2009	Dairy farmers in the Northeast region filed class action antitrust lawsuits.
2011	Settlement agreement was reached between Dean and dairy farmers in the Northeast.
2012	Settlement agreement was reached between Dean and dairy farmers in the Southeast.
2013	Settlement agreement was reached between DFA and dairy farmers in the Southeast.
2014-2016	Settlement agreement was reached between DFA and dairy farmers in the Northeast.
2013-2016	Dairy farmers in the Southeast received payments.
2018	Dairy farmers in the Northeast received payments.

[1] The Sherman Act (1890) and the Capper-Volstead Act (1922) are discussed in Appendix 1.

[2] The Southern Marketing Agency (SMA) paid an additional $5 million. DFA agreed to put a refundable $9.3 million per year for two years in a fund to increase the Class I milk utilization rate in Federal Milk Marketing Orders 5 and 7.

[3] The changes, which directly affect the competition process, included changes to milk supply agreements and, in particular, full supply agreements. The settlement agreements include some restrictions on DFA entering into new full supply agreements and renewing existing full supply agreements during the settlement terms.

of current restructuring in the industry. Dean Foods filed for bankruptcy in fall 2019 (Lucas 2019; Valinsky 2019). Dairy Farmers of America acquired a substantial portion of Dean's assets in spring 2020 (McClain 2020; U.S. Department of Justice 2020). DFA is to become the largest supplier of raw milk used in fluid milk product manufacturing and the largest processor and marketer of fluid milk products in the country.

The case study has four student learning objectives (SLOs):

- SLO #1: Students should be able to describe recent structural changes in the fluid milk industry in the Eastern United States and the United States and competition concerns raised by dairy farmers in the most recent antitrust litigations.
- SLO #2: Using a graphical analysis, students should be able to apply a marketing margin (theoretical) framework to explain the conduct and performance of the fluid milk processing industry in two market scenarios: a competitive industry scenario and a market power scenario, which incorporates both the buyer and seller market power of fluid milk processors. They also should be able to identify the effects of market power on dairy farmers, retailers, and final consumers.
- SLO #3: Students should be able to locate sources of market and price data for the fluid milk industry on the U.S. Department of Agriculture Agricultural Marketing Service webpages.
- SLO #4: Students should be able to use data reported in the case study to conduct selected elements of market and price analysis presented in the case study. In particular, students should be able to calculate over-order premiums received by dairy farmers and farm-to-retail margins in the two periods of interest (the pre-antitrust action period and the antitrust action period) as well as calculate changes in milk prices, quantities, premiums, and margins between these two periods. Students should be able to explain the results of their analysis.

2 Federal Milk Marketing Orders and Fluid Milk Industry: United States and Eastern United States

The system of Federal Milk Marketing Orders (FMMOs) regulates marketing and pricing of Grade A milk at the farm-first handler level in the United States.[4] The two main features of FMMOs are classified pricing and pooling of milk. Grade A milk produced by dairy farmers is divided into four Classes, depending on the end-use of milk (i.e., the type of processed products). Class I milk is used to manufacture fluid (beverage) milk products (whole milk, reduced-fat milk, skim milk, and so on). Class II milk is used to manufacture soft dairy products (yogurt, sour cream, cottage cheese, ice-cream, and so on). Class III milk is used to manufacture hard dairy products (cheese and cream cheese). Class IV milk is used to manufacture butter and milk products in dry and evaporated forms.

FMMOs are used to determine minimum prices that regulated milk handlers (processors) have to pay for Grade A milk. Class I milk has the highest price. Dairy farmers do not receive Class milk prices directly; instead, these prices and the rates of milk utilization in each class determine uniform prices (blend prices) for each FMMO. The uniform price is the minimum milk price that dairy farmers within the same Order receive. Dairy cooperatives are allowed to negotiate premiums (over-order premiums), which are added to the FMMOs' minimum prices. Over-order premiums are paid based on milk quality,

[4] FMMOs are geographically defined areas based on the demand for fluid milk products. Currently there are 11 FMMOs, which regulate the marketing of approximately 75 percent of total milk production (USDA AMS 2021a). The objectives of FMMOs are to create orderly marketing conditions for fluid milk products and to ensure sufficient supplies of quality milk at reasonable prices for final consumers as well as to improve terms of trade and the bargaining process between milk producers and milk processors and to increase returns to dairy farmers. FMMOs are authorized in the Agricultural Marketing Agreement Act (1937). A comprehensive discussion of Federal Milk Marketing Orders is presented in CRS (2017). Practically, all milk produced in the United States is Grade A milk.

volume, and milk assembling services provided by dairy cooperatives. Over-order premiums are typically paid on Class I milk, so they also reflect supply and demand conditions in the local fluid milk markets. Class milk prices and uniform prices are calculated and announced on a monthly basis.

The anticompetitive conduct of DFA and Dean, analyzed in this case study, affected the purchase, sale, marketing, and processing of Grade A milk utilized as Class I (fluid milk) in Federal Milk Marketing Order 5 (FO5 Appalachian) and Federal Milk Marketing Order 7 (FO7 Southeast), collectively referred to as the Southeast, and Federal Milk Marketing Order 1 (FO1 Northeast). Figure 1 is a map of Federal Milk Marketing Orders.

Table 2 summarizes key marketing and price data for 10 FMMOs for 2013.[5] These data indicate the key differences among the 10 FMMOs in terms of total milk quantity marketed, Class I milk quantity marketed, Class I milk utilization rate (percentage of milk used as Class I milk), and Class I milk price and uniform price.[6] Dairy farmers located in the three analyzed FMMOs produced 28 percent of the FMMOs' total milk and 41 percent of the FMMOs' Class I milk. In these three FMMOs, Class I milk utilization rates were higher than those in all the other FMMOs: 37 percent in FO1 (Northeast), 67 percent in FO5 (Appalachian), and 68 percent in FO7 (Southeast). Class I milk prices and Class I milk utilization rates directly affect uniform prices. Uniform prices in the analyzed FMMOs were above the FMMOs' average uniform price, and these prices were higher than those in all other FMMOs.[7]

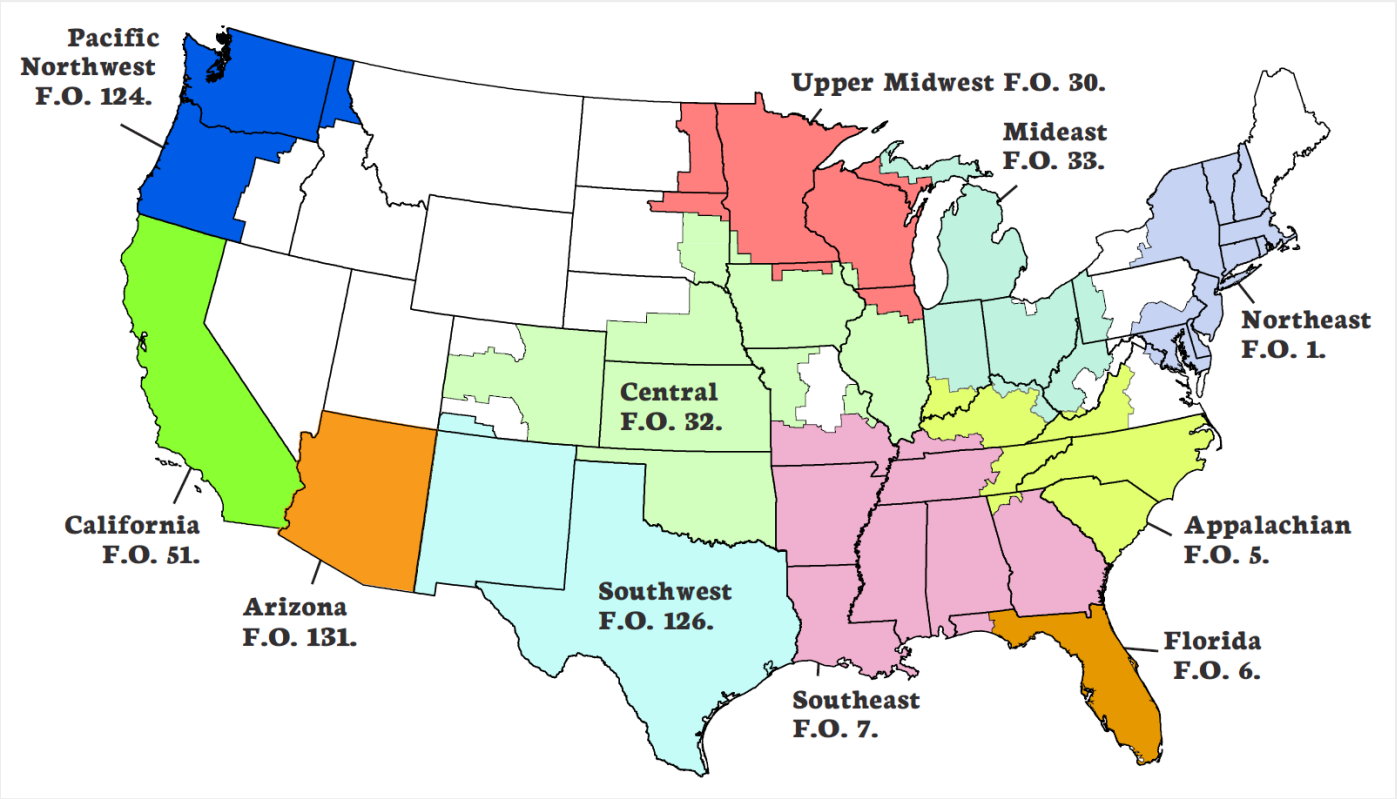

Figure 1. Map of Federal Milk Marketing Orders (USDA AMS 2021b)

[5] The earliest year for which this type of summary data is available online is 2013 (USDA AMS Dairy Program 2014).
[6] "Total milk quantity" refers to a combined quantity of Class I milk, Class II milk, Class III milk, and Class IV milk. The total milk quantity and Class I milk quantity are the quantities produced by milk producers (dairy farmers) located in a particular Order.
[7] Among FMMOs, FO6 Florida has the highest Class I milk utilization rate as well as the highest Class I milk price and uniform milk price.

Table 2. Federal Milk Marketing Orders: Market Summary (2013)

FMMO	Total milk quantity	Class I milk quantity	Class I milk utilization rate	Class I milk price	Uniform price
	millions of pounds	millions of pounds	percent	$/cwt	$/cwt
Northeast	**25,420**	**9,508**	**37**	**22.09**	**20.23**
Appalachian	**5,729**	**3,845**	**67**	**22.24**	**21.34**
Florida	2,833	2,424	86	24.24	23.53
Southeast	**6,129**	**4,163**	**68**	**22.64**	**21.74**
Upper Midwest	34, 315	3,686	11	20.64	18.29
Central	15,199	4,867	32	20.85	18.82
Mideast	16,719	6,448	39	20.85	19.17
Pacific Northwest	8,239	2,120	26	20.74	18.83
Southwest	12,901	4,324	33	21.85	19.59
Arizona	4,615	1,357	29	21.19	19.41
Market average or total	**132,100**	**42,742**	**32**	**21.70**	**19.44**

Data Source: USDA AMS Dairy Program (2014).

3 Fluid Milk Industry in the United States and Eastern United States: Structural Changes and Business Conduct of Fluid Milk Processors

This section discusses the structure of the fluid milk industry and structural changes in the industry as well as competition issues related to the business conduct of Dean Foods and Dairy Farmers of America revealed during antitrust litigations in the Southeast and Northeast regions.

3.1 Structural Changes in the U.S. Fluid Milk Industry

During the 1980s and 1990s, increasing consolidation and concentration affected the fluid milk industry in the United States. The number of firms operating at milk production and at fluid milk processing and retailing stages of the fluid milk supply chain decreased, and firm size increased. A number of firms engaged in a string of mergers, acquisitions, and joint ventures.[8]

The combined market shares of the four largest firms increased at all stages of the fluid milk supply chain and reached their highest level by the beginning of 2000.[9] For example, in 1999, the average

[8] Dobson (1992), Dobson and Christ (2000), U.S. General Accounting Office (2001) and U.S. Government Accountability Office (2004), Gould (2010), and Shields (2010) discuss structural changes in the U.S. fluid milk industry and firms' competitive strategies.

[9] The combined market share of the four largest firms in the industry is referred to as the four-firm concentration ratio (CR4). The *N*-firm concentration ratio, a commonly used measure of market concentration, represents a combined market share of

market share of the four largest dairy cooperatives reported for 11 U.S. markets was 76.5 percent, and the average market share of the four largest fluid milk processors reported for 14 U.S. markets was 75.6 percent (U.S. General Accounting Office 2001). In 2003, the average market share of the four largest fluid milk retailers reported for 15 U.S. markets was 73.9 percent (U.S. Government Accountability Office 2004).

Dairy cooperatives have historically been involved in milk marketing in the United States.[10] The economic objective of farmer-owned cooperatives is to increase returns to their farmer-members. Dairy cooperatives are obligated to accept and sell all milk of their farmer-members and to obtain the highest-possible milk prices, which dairy farmers are not able to negotiate individually. Many dairy cooperatives perform bargaining functions by representing farmer-members in contract negotiation processes with dairy processors. Dairy cooperatives negotiate over-order premiums and other terms of trade. Collective marketing activities of dairy farmers implemented through dairy cooperatives, including price negotiations with dairy processors, are possible due to the Capper-Volstead Act (1922), a limited antitrust immunity from the Sherman Act (1890).

Dairy Farmers of America (DFA) is the largest dairy cooperative in the country. It was formed in 1998 as a result of the merger of four large regional dairy cooperatives (U.S. General Accounting Office 2001; Gould 2010). DFA, a vertically integrated cooperative, owns and operates fluid milk processing plants. In 2000, DFA had net sales of $6.76 billion.

Suiza Foods Corporation and Dean Foods Company were the two largest fluid milk processors in the United States prior to Suiza's acquisition of Dean. Suiza owned and operated 67 dairy processing plants in 29 states, and in 2000 it had net sales of $5.76 billion.[11] Dean owned and operated 43 dairy processing plants in 19 states, and in 2000 it had net sales of $4.4 billion.[12]

In 2001, Suiza Foods Corporation acquired Dean Foods Company, creating a new company: Dean Foods. To protect competition for fluid milk sold through schools and retail outlets, the U.S. Department of Justice (DOJ) conditioned approval of this merger on Suiza and Dean selling 11 fluid milk processing plants (U.S. Department of Justice 2001). These plants, which were located in Alabama, Florida, Indiana, Kentucky, Ohio, South Carolina, Virginia, and Utah, were divested to National Dairy Holdings (NDH). NDH was a newly formed company, 50 percent owned by DFA. The new Dean (a publicly traded company) became the largest fluid milk processor in the United States.

3.2 Fluid Milk Industry in the Southeast: Early 2000s

In 2000, there were 4,808 dairy farmers in FO7 (Southeast) and 4,483 dairy farmers in FO5 (Appalachian).[13] In 1999, the combined market shares of the four largest dairy cooperatives were 71.5 percent in Atlanta and New Orleans and 85.2 percent in Charlotte (U.S. General Accounting Office

the *N* largest firms in the industry (Besanko et al. 2006). CR4 (*N*=4) is the most frequently used measure. The firms' market shares are typically calculated using the firms' revenue (sales). A high level of market concentration can facilitate anticompetitive conduct. An industry with a CR4 that exceeds 75 percent is thought to be prone to collusion; an industry with a CR4 lower than 40 percent likely presents no competition concerns (Hovenkamp 2005). A problem with using CR is that it does not account for the size inequality among the largest firms. The Herfindahl–Hirschman Index (HHI), another commonly used measure of market concentration, does account for this inequality. HHI is the sum of the squared market shares of the largest firms in the industry (Hovenkamp 2005; Besanko et al. 2006).

[10] The types of dairy cooperatives differ due to the scope of functions performed: bargaining, niche marketing, processing, and diversified (USDA RD 2005; Liebrand 2010; Ling 2012).

[11] During the 1990s, Suiza used an aggressive strategy of acquiring fluid milk processing plants, as a result of which Suiza became the largest fluid milk processor in the country (Siebert et al. 2000).

[12] The number of fluid milk processing plants and net sales for DFA, Suiza, and Dean are reported in U.S. Department of Justice (2001).

[13] The number of dairy farmers is reported in the annual statistics of FO5 and FO7 (USDA AMS Dairy Program 2019b, c).

2001).[14] In 1999, the combined market shares of the four largest fluid milk processors were 52.4 percent in Atlanta and New Orleans and 73.9 percent in Charlotte (U.S. General Accounting Office 2001). In 2003, the combined market shares of the four largest fluid milk retailers were 74.7 percent in New Orleans, 78.2 percent in Atlanta, and 82 percent in Charlotte (U.S. Government Accountability Office 2004).

Dean was the largest fluid milk processor (fluid milk bottler) in the Southeast.[15] It owned approximately 17 fluid milk bottling plants and controlled approximately 60 percent of the fluid milk bottling capacity in the region. National Dairy Holdings (NDH) was the second-largest fluid milk bottler in the Southeast. It owned approximately nine fluid milk bottling plants in the Southeast. DFA was the third-largest fluid milk bottler in the Southeast. It operated at least eight fluid milk bottling plants in the region. In addition, DFA controlled the supply of approximately 90 percent of Grade A milk in the region. Together, these three fluid milk processors operated at least 33 plants, which represented approximately 77 percent of the fluid milk bottling capacity in the Southeast. Dairy Marketing Services (DMS) and the Southern Marketing Agency (SMA) were the two marketing agencies involved in milk marketing in this region.

3.3 Fluid Milk Industry in the Northeast: Early 2000s

In 2000, there were 17,279 dairy farmers in FO1 (Northeast).[16] In 1999, the combined market shares of the four largest dairy cooperatives were 69.6 percent in Boston and 76.8 percent in Washington, D.C. (U.S. General Accounting Office 2001).[17] In 1999, the combined market shares of the four largest fluid milk processors were 54.5 percent in Washington, D.C. and 88.1 percent in Boston (U.S. General Accounting Office 2001). In 2003, the combined market shares of the four largest fluid milk retailers were 70.1 percent in Boston and 76.5 percent in Washington, D.C. (U.S. Government Accountability Office 2004).

Dean was the largest fluid milk bottler in the Northeast.[18] National Dairy Holdings (NDH) and HP Hood were the two other large fluid milk processors operating in this region. DFA had approximately 1,900 farmer-members in the Northeast. Dairy Marketing Services (DMS), a marketing agency, marketed milk for 9,000 dairy farmers, including independent dairy farmers and other cooperatives. DMS marketed approximately 60 percent of milk delivered to fluid milk processing plants in the Northeast. DMS was owned by DFA and two other dairy cooperatives.

3.4 Business Conduct of Dairy Farmers of America (DFA) and Dean Foods (Dean) in the Eastern United States: Competition Issues

In a competitive market environment, dairy farmers should have the following marketing options: to market their milk independently by selling it directly to fluid milk processors, to market their milk through a dairy cooperative, or to market their milk through a marketing agency. Milk prices received by dairy farmers are determined within the system of Federal (and State) Milk Marketing Orders, which guarantees the same milk price for all dairy farmers located in a given Order. Premiums are negotiated for milk quality characteristics and volume and for milk assembling services provided by dairy cooperatives.

[14] The U.S. General Accounting Office (2001) and the U.S. Government Accountability Office (2004) report concentration ratios only for selected markets. Atlanta (GA), New Orleans (LA), and Charlotte (NC) are located in the Southeast region covered by FO5 and FO7.

[15] The information presented in this paragraph is obtained from the complaint filed by dairy farmers with the court in the Southeast region: *Sweetwater Valley Farm, Inc., et al v. Dean Foods Company et al.*

[16] The number of dairy farmers is reported in the annual statistics of FO1 (USDA AMS Dairy Program 2019a).

[17] The U.S. General Accounting Office (2001) and the U.S. Government Accountability Office (2004) report concentration ratios only for selected markets. Boston (MA) and Washington D.C. are located in the Northeast region covered by FO1.

[18] The information presented in this paragraph is obtained from the complaint filed by dairy farmers with the court in the Northeast region: *Allen et al v. Dairy Farmers of America, Inc. et al.*

In their complaints filed with the courts, dairy farmers claimed that the following activities of DFA, Dean, other fluid milk processors, and milk marketing agencies restricted competition in the fluid milk industry in the Southeast and Northeast regions:[19]

- Entered full-supply agreements and used long-term full supply agreements between them to control dairy farmers' access to fluid milk bottling plants.[20]
- Decreased and stabilized prices paid to dairy farmers for Grade A milk used as Class I milk and in particular, decreased and fixed the amount of over-order premiums paid for Class I milk.
- Required dairy farmers (independent dairy farmers and independent cooperatives) to market their milk only through DFA or DFA-controlled entities (marketing agencies controlled by DFA) to gain access to fluid milk bottling plants.
- Foreclosed (precluded) the access of independent dairy farmers and independent dairy cooperatives to fluid milk bottling plants—access required for dairy farmers to qualify for the FMMOs' minimum prices.
- Threatened, punished, and boycotted independent dairy farmers, independent cooperatives, and fluid milk bottlers who did not comply with the efforts to control these entities.
- Used DFA-controlled entities (marketing agencies controlled by DFA) to monitor prices paid to independent dairy farmers and independent cooperatives.
- Purchased fluid milk bottling plants, closed fluid milk bottling plants, and refused to operate fluid milk bottling plants.
- "Flooded" Southeast with Grade A milk from other regions, allegedly decreasing Class I milk utilization rate in FO5 and FO7, which consequently decreased milk prices paid to dairy farmers.

In addition, dairy farmers claimed that DFA, instead of maximizing returns to dairy farmer-members, acted in the manner of a profit-maximizing fluid milk processor—one that benefited from decreasing its costs by decreasing milk quantity purchased from dairy farmers and by decreasing milk prices paid to dairy farmers, in particular, over-order premiums paid for raw milk used as Class I milk.

In summary, dairy farmers argued that the above-noted conduct of DFA and Dean considerably restricted marketing options for dairy farmers and limited their access to fluid milk processing (bottling) plants. This conduct might have decreased the quantity of raw milk (used as Class I milk) sold by dairy farmers and purchased by fluid milk processors in the analyzed regions, which in turn might have decreased over-order premiums and milk prices paid by fluid milk processors to dairy farmers.

4 Theoretical Framework: Market Power of Fluid Milk Processors

Figure 2 presents a theoretical framework for explaining the conduct and performance of the fluid milk industry in light of structural changes (increasing consolidation and concentration) and competition

[19] Complete lists of allegedly anticompetitive practices are presented in the complaints filed by dairy farmers with the courts: *Sweetwater Valley Farm, Inc., et al v. Dean Foods Company et al. (Southeast)* and *Allen et al v. Dairy Farmers of America, Inc. et al. (Northeast).*

[20] A full supply agreement between a fluid milk processor, for example, Dean, and DFA means that DFA is the only supplier of milk for Dean's fluid milk bottling plants. Independent dairy farmers and independent dairy cooperatives do not have access to these fluid milk bottling plants. Their options are either to join DFA or DFA-controlled entities or to exit the industry.

issues raised by dairy farmers.[21] This framework is a marketing margin framework.[22] It includes (as applied to the fluid milk supply chain) the dairy farm level represented by dairy farmers producing raw milk and the fluid milk processing level represented by fluid milk processors purchasing raw milk from dairy farmers and processing it into fluid milk products.[23] It also includes the retail level represented by retailers purchasing fluid milk products from fluid milk processors and selling them to final consumers.[24] The farm supply curve represents the inverse supply function for raw milk at the farm level. The wholesale demand curve represents the inverse demand function for fluid milk products at the wholesale level. The retail demand curve represents the inverse demand function for fluid milk products at the retail level.

The two market scenarios are introduced below. The first is a competitive industry scenario in which there are many fluid milk processors, none of which possess any market power. The second is a market power scenario in which there is a small number of large fluid milk processors that possess buyer and seller market power.

Scenario #1: The fluid milk processing industry is a competitive industry.

Assume that the fluid milk processing industry is a competitive industry with many fluid milk processors. These processors purchase a quantity of raw milk (Class I milk quantity) denoted as Qc in Figure 2. They pay to dairy farmers the raw milk price (Class I milk price) denoted as FPc. Fluid milk processors process raw milk into fluid milk products and sell a quantity of fluid milk products denoted as Qc to retailers.[25] Fluid milk processors charge the wholesale price for fluid milk products denoted as WPc. Retailers sell a quantity of fluid milk products denoted as Qc to final consumers and charge the retail price denoted as RPc.[26] In a competitive industry scenario, the marketing margin attributed to fluid milk processors is WPc – FPc in $ per unit and (WPc – FPc)*Qc in total $. This marketing margin (farm-to-wholesale margin) includes the fluid milk processing costs and profit of fluid milk processors. The two additional marketing margins shown in Figure 2 are the wholesale-to-retail margin, RPc - WPc in $ per unit and (RPc - WPc)*Qc in total $, and the farm-to-retail margin, RPc-FPc in $ per unit and (RPc-FPc)*Qc in total $.[27]

[21] The competition concerns raised by dairy farmers were related to buyer market power of fluid milk processors. The competition issues related to seller market power of fluid milk processors were raised by dairy retailers in their lawsuit filed against Dean and DFA, among other defendants (Goldfein and Keyte 2014; Hurley 2017). After complex legal proceedings, the lawsuit was settled.

[22] Graphically, this framework is a simplified version of a graphical representation 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 textbooks (for example, see Besanko and Braeutigam 2002). For simplicity, the marginal revenue curve for monopoly and the marginal expenditure curve for monoposony are not shown in Figure 2. The marketing margin framework, as applied to agricultural and food industries, is discussed in Kohls and Uhl (2002), Hudson (2007), and Tomek and Kaiser (2014).

[23] Fluid milk products include whole milk, reduced-fat milk, low-fat milk, flavored milk, and other types of fluid milk products considered to be "beverage" milk.

[24] The structure of the fluid milk supply chain is shown in Figure A2.1.

[25] Qc does not occur at the intersection of farm supply and wholesale demand because inverse farm supply is for raw milk used in fluid milk manufacturing and wholesale demand is for fluid milk products. At Qc, the distance between WPc and FPc in Figure 2 is the farm-to-wholesale margin measured in $ per unit.

[26] In fluid milk processing, one unit of input (raw milk) is required to produce one unit of output (fluid milk products). Fluid milk processing (manufacturing) is also referred to as a fluid milk bottling business. Therefore, Q is used to denote milk quantity corresponding to the dairy farm, wholesale, and retail levels of the fluid milk supply chain.

[27] The wholesale-to-retail margin includes the retailing costs and profit of food retailers. The farm-to-retail margin is the sum of the farm-to-wholesale margin and the wholesale-to-retail margin.

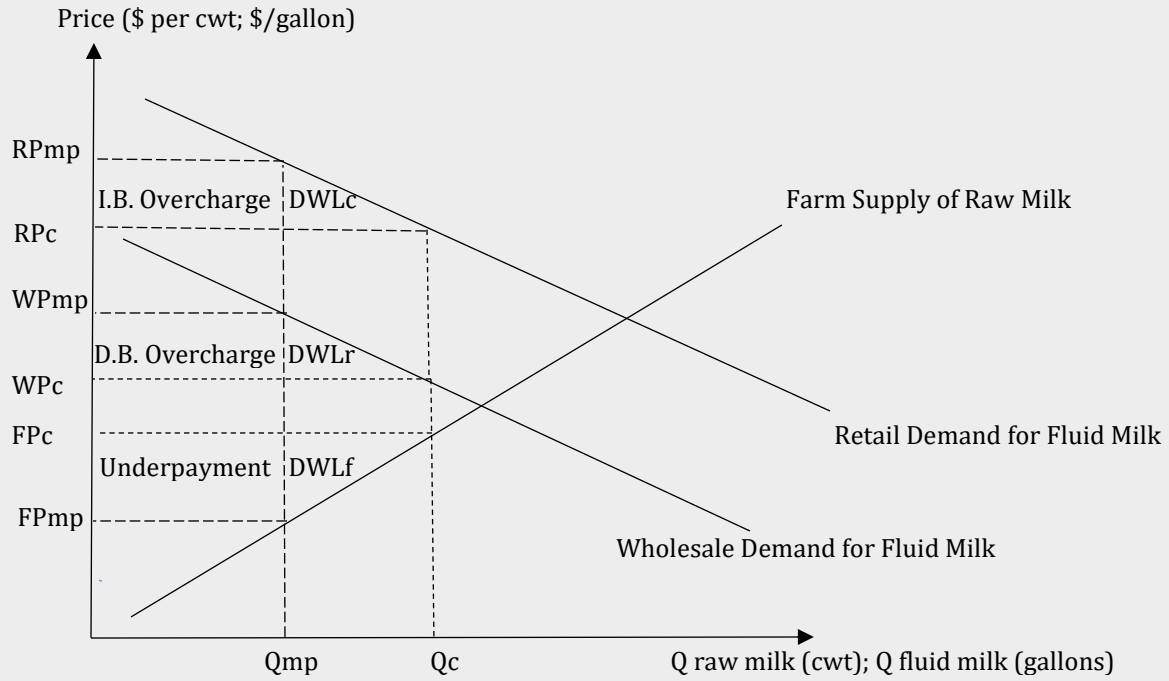

Figure 2. Price Effects of Market Power in the Fluid Milk Processing Industry

Scenario #2: The fluid milk processing industry is an imperfectly competitive industry. The industry has buyer market power in the market for raw milk (input market) and seller market power in the market for fluid milk products (output market).

Assume that as a result of mergers and acquisitions the number of fluid milk processors decreases, and the size of remaining firms increases. There are a small number of large fluid milk processors in the industry. The fluid milk processing industry is an oligopsony on the input side (raw milk purchasing) and an oligopoly on the output side (fluid milk product marketing). As compared with a competitive industry, oligopsonists maximize their profit by decreasing the input quantity they purchase to lower the input price they pay (buyer market power affecting inverse supply). To maximize their profit, oligopolists decrease the output quantity they produce and sell to increase the output price they charge (seller market power affecting inverse demand).

In the market power scenario, fluid milk processors purchase a quantity of raw milk (Class I milk quantity) denoted as Qmp and pay to dairy farmers the raw milk price (Class I milk price) denoted as FPmp in Figure 2. Fluid milk processors process raw milk into fluid milk products. They sell a quantity of fluid milk products denoted as Qmp to retailers and charge the wholesale price denoted as WPmp. Retailers sell a quantity of fluid milk products denoted as Qmp to final consumers and charge the retail price denoted as RPmp. In the market power scenario, the marketing margin (farm-to-wholesale margin) attributed to fluid milk processors is WPmp – FPmp in $ per unit and (WPmp – FPmp)*Qmp in total $. The two additional marketing margins shown in Figure 2 are the wholesale-to-retail margin, RPmp-WPmp in $ per unit and (RPmp-WPmp)*Qmp in total $, and the farm-to-retail margin, RPmp-FPmp in $ per unit and (RPmp-FPmp)*Qmp in total $.

As compared with a competitive industry, dairy farmers who sell milk are underpaid due to the buyer market power of fluid milk processors. The underpayment to dairy farmers is FPc-FPmp in $ per unit and (FPc-FPmp)*Qmp in total $. The total $ amount underpaid to dairy farmers due to a reduction in milk quantity purchased by fluid milk processors is represented by the underpayment rectangle in Figure

2.[28] Dairy farmers who do not sell milk, due to a reduction in milk quantity purchased by fluid milk processors, likely exit the market. The deadweight loss (DWL) attributed to the dairy farm sector is represented by the DWLf triangle in Figure 2.[29]

As compared with a competitive industry, retailers (direct buyers) and final consumers (indirect buyers) are overcharged due to the seller market power of fluid milk processors. The overcharge attributed to retailers (direct buyers) is WPmp-WPc in $ per unit and (WPmp-WPc)*Qmp in total $. The total $ amount that retailers overpaid due to a reduction in fluid milk quantity sold by fluid milk processors is represented by the overcharge rectangle denoted as "D.B. overcharge" in Figure 2.[30] The overcharge attributed to final consumers (indirect buyers) is RPmp-RPc in $ per unit and (RPmp-RPc)*Qmp in total $. The total $ amount that final consumers overpaid due to a reduction in fluid milk quantity is represented by the overcharge rectangle denoted as "I.B. overcharge" in Figure 2. Some retailers and final consumers do not purchase fluid milk products due to a reduction in fluid milk quantity sold by fluid milk processors. The deadweight loss attributed to the retail sector and the deadweight loss attributed to final consumers are represented by the DWLr and DWLc triangles, respectively, in Figure 2.

Buyer market power increases the profit of fluid milk processors by the amount of underpayment to dairy farmers. Seller market power increases the profit of fluid milk processors by the amount of overcharge attributed to buyers of fluid milk products. There is also a deadweight loss attributed to the fluid milk processing sector.

The competition concerns raised by dairy farmers were related to the buyer market power of fluid milk processors. As compared with a competitive industry, fluid milk processors decrease the quantity of Class I milk they purchase, which decreases the Class I milk price they pay. Dairy farmers sell a smaller Class I milk quantity, leading to a lower Class I milk price.[31] Given that the milk price received by dairy farmers includes the FMMO minimum price and over-order premiums, the buyer market power of fluid milk processors decreases the amount of over-order premiums, and consequently it decreases the milk price received by dairy farmers. In addition, some dairy farmers exit the market.

The activities of DFA and Dean (those presented in the complaints) that have affected and that might have decreased the Class I milk quantity available in the market and purchased include the following: (a) using full-supply agreements and long-term full supply agreements between DFA and Dean to control dairy farmers' access to fluid milk bottling plants, (b) requiring dairy farmers to market their milk only through DFA or DFA-controlled entities (marketing agencies controlled by DFA) in order to gain access to fluid milk bottling plants, (c) foreclosing (precluding) dairy farmers' access to fluid milk bottling plants, and (d) purchasing fluid milk bottling plants, closing fluid milk bottling plants, or refusing to operate fluid milk bottling plants.

The economic incentives for DFA and Dean to use these business practices in the fluid milk industry in the Southeast and Northeast regions were to decrease milk costs in order to increase the profit of fluid milk manufacturing. As compared with the FMMOs averages, the Southeast and Northeast regions have the highest Class I milk utilization rates, the highest Class I milk prices, and the highest uniform prices, thus leading to higher costs that fluid milk processors have to incur in these regions

[28] The underpayment (in $ per unit) is a price decrease due to a quantity decrease. Supply elasticity (reflected in the steepness of the supply curve on a graph) will affect the magnitude of price decrease.

[29] Deadweight loss (DWL) measured in monetary units is the loss of economic benefits for all sellers or all buyers of the analyzed product. DWL is a decrease in the producer surplus or the consumer surplus or both. In this case study, DWL is due to a decrease in milk quantity purchased and marketed by fluid milk processors because of their buyer and seller market power.

[30] The overcharge (in $ per unit) is a price increase due to a quantity decrease. Demand elasticity (reflected in the steepness of the demand curve on a graph) will affect the magnitude of price increase.

[31] FMMOs' minimum Class milk prices are calculated with a series of formulas, which include wholesale prices of manufactured dairy products (cheese, butter, dry whey, and nonfat dry milk) (USDA AMS Dairy Program 2017).

(Table 2).

5 Fluid Milk Market and Price Behavior: Empirical Analysis

This section presents a basic empirical market and price analysis using publicly available data reported by the U.S. Department of Agriculture Agricultural Marketing Service. The analysis is conducted at the farm and retail levels of the fluid milk supply chain. The farm level analysis focuses on the number of dairy farmers, milk quantities, milk prices (table 3, yearly data), and over-order premiums paid to dairy farmers (tables 4 and 5, monthly data).[32] The retail level analysis focuses on retail fluid whole milk prices and farm-to-retail margins (tables 6 and 7, monthly data).

First, the averages of the economic variables are calculated for the two periods of interest: the pre-antitrust action period (the period of allegedly anticompetitive conduct of fluid milk processors) and the antitrust action period (the period of antitrust litigations). Second, the changes in the averages between these two periods are calculated. In light of the theoretical framework used in the present analysis, the pre-antitrust action period can be thought of as a market power scenario (a lesser degree of competition among fluid milk processors due to their anticompetitive conduct), and the antitrust action period may be thought of as a competitive industry scenario.[33]

5.1 Farm-Level Effects: Milk Producer Numbers, Milk Quantities, and Milk Prices (Table 3) [34]

This section discusses changes in the analyzed economic variables in the antitrust action period, as compared with the pre-antitrust action period.[35]

5.1.1 FO7 Southeast

The yearly average number of milk producers (dairy farmers) in FO7 decreased from 3,688 to 2,356. The yearly average Class I milk quantity decreased from 4,718 million pounds to 4,177 million pounds. The yearly average Class I milk utilization rate increased from 63.1 percent to 69.2 percent. The yearly average Class I milk price increased from $17.42 per cwt to $20.60 per cwt.

[32] The results reported in tables 3–7 were generated in Excel. If selected calculations are reproduced using a calculator, results might be slightly different than those reported here.

[33] The market and price behavior might not change significantly during the antitrust action period, as compared with the pre-antitrust action period. However, for teaching purposes, it may be assumed that the threat of antitrust litigations and potential penalties made fluid milk processors behave more competitively.

[34] The original data analyzed in this section were collected from statistical materials available on the webpages of the analyzed Federal Milk Marketing Orders (USDA AMS Dairy Program 2019a, b, c).

[35] In the case of the Southeast region, the pre-antitrust action period is 2001 to 2008, and the antitrust action period is 2009 to 2018. In the case of the Northeast region, the pre-antitrust action period is 2002 to 2009, and the antitrust action period is 2010 to 2018. The beginning of the pre-antitrust action period (in the case of each region) is the year when the allegedly anticompetitive conduct of Dean and DFA began affecting fluid milk markets, according to the complaints filed by dairy farmers with the courts. The beginning of the antitrust action period (in the case of each region) is the year when complaints were filed by dairy farmers with the courts.

Table 3. Market Analysis for Federal Milk Marketing Order 7 "Southeast," Federal Milk Marketing Order 5 "Appalachian" and Federal Milk Marketing Order 1 "Northeast" (2000-2018)

Measure	Units	Pre-antitrust action period Average	Antitrust action period Average	Change in the Average between the two periods (percentage change)
Federal Milk Marketing Order 7				
Number of milk producers	number	3,688	2,356	-1,332 (-36.1)
Class I milk producer quantity	million pounds	4,718	4,177	_____(_____)
Total milk producer quantity	million pounds	7,497	6,069	-1,428 (-19)
Class I milk utilization	percent	63.1	69.2	_____(_____)
Class I milk price	$/cwt	17.42	20.6	_____(_____)
Uniform price	$/cwt	16.27	19.57	3.3 (20.3)
Federal Milk Marketing Order 5				
Number of milk producers	number	3,266	2,231	-1,035 (-31.7)
Class I milk producer quantity	million pounds	4,269	3,985	_____(_____)
Total milk producer quantity	million pounds	6,286	5,808	-478 (-7.6)
Class I milk utilization	percent	68	68.6	_____(_____)
Class I milk price	$/cwt	17.4	20.2	_____(_____)
Uniform price	$/cwt	16.3	19.21	2.86 (17.5)
Federal Milk Marketing Order 1				
Number of milk producers	number	14,757	12,055	-2,701 (-18.3)
Class I milk producer quantity	million pounds	10,549	9,352	_____(_____)
Total milk producer quantity	million pounds	23,591	25,794	2,204 (9.3)
Class I milk utilization	percent	44.8	36.4	_____(_____)
Class I milk price	$/cwt	17.16	20.64	_____(_____)
Uniform price	$/cwt	15.34	18.59	3.24 (21.1)

Data source: USDA AMS Dairy Program (2019a, b, c).
Note 1: Southeast region: the pre-antitrust action period is 2001 to 2008, and the antitrust action period is 2009 to 2018
Northeast region: the pre-antitrust action period is 2002 to 2009, and the antitrust action period is 2010 to 2018.
Note 2: Students have to perform relevant calculations to record their answers in cells with missing answers (Discussion Question 4.1).

5.1.2 FO5 Appalachian

The yearly average number of milk producers (dairy farmers) in FO5 decreased from 3,266 to 2,231. The yearly average Class I milk quantity decreased from 4,269 million pounds to 3,985 million pounds. The yearly average Class I milk utilization rate increased from 68 percent to 68.6 percent. The yearly average Class I milk price increased from $17.40 per cwt to $20.20 per cwt.

5.1.3 FO1 Northeast

The yearly average number of milk producers (dairy farmers) in FO1 decreased from 14,757 to 12,055. The yearly average Class I milk quantity decreased from 10,549 million pounds to 9,352 million pounds. The yearly average Class I milk utilization rate decreased from 44.8 percent to 36.4 percent. The yearly average Class I milk price increased from $17.16 per cwt to $20.64 per cwt.

5.2 Farm-Level Effects: Over-Order Premiums

The Class I milk prices analyzed in the previous section are the FMMO minimum prices that fluid milk processors have to pay. Dairy cooperatives negotiate with fluid milk processors premiums (over-order

premiums or over-order payments) that are paid in addition to the FMMO minimum Class I milk prices. Over-order premiums increase the revenue and profitability of dairy farmers. The premium measured in $ per cwt of milk[36] is calculated as the difference between the announced cooperative Class I milk price and FMMO minimum Class I milk price reported for a particular geographic location.[37] The premium is also calculated as a percentage of the announced cooperative Class I milk price. Given that the analyzed premiums are calculated using the *announced* cooperative prices, *actual* premiums paid might be different.

5.2.1 Southeast Region: FO5 and FO7 Selected Markets (Table 4)[38]

During the pre-antitrust action period, the monthly average premiums are $1.70 per cwt in New Orleans, $1.77 per cwt in Memphis, $1.85 per cwt in Louisville, $1.93 per cwt in Charlotte, and $1.97 per cwt in Atlanta.[39] The monthly average premium expressed as a percentage of the cooperative Class I milk price is in the range of 9 percent to10 percent in the majority of the analyzed cities in the Southeast region.

The monthly average premiums measured in $ per cwt and as a percentage of the cooperative Class I milk prices increase in all analyzed cities in the antitrust action period, as compared with the pre-antitrust action period. In the antitrust action period, the monthly average premiums are $2.94 per cwt in New Orleans, $3.11 per cwt in Louisville, $3.24 per cwt in Charlotte, $3.30 per cwt in Memphis, and $3.32 per cwt in Atlanta. The monthly average premium expressed as a percentage of the cooperative Class I milk price is in the range of 14 percent to 15 percent in the majority of the analyzed cities in the Southeast region.

5.2.2 Northeast Region: FO1 Selected Markets (Table 5)[40]

During the pre-antitrust action period, the monthly average premiums are $1.55 per cwt in Boston and Harford, $1.78 per cwt in Baltimore and Washington D.C., and $2.20 per cwt in Philadelphia. The monthly average premium expressed as a percentage of the cooperative Class I milk price is in the range of 8 percent to10 percent in the majority of the analyzed cities in the Northeast region.

The monthly average premium measured in $ per cwt increases in Boston, Hartford, and Philadelphia and decreases in Baltimore and Washington D.C. in the antitrust action period, as compared with the pre-antitrust action period. The monthly average premium calculated as a percentage of the cooperative Class I milk price decreases in Boston, Hartford, Baltimore, and Washington D.C. and increases in Philadelphia in the antitrust action period, as compared with the pre-antitrust action period.

In the antitrust action period, the monthly average premiums are $1.61 per cwt in Boston and Harford, $1.67 per cwt in Baltimore and Washington D.C., and $3.09 per cwt in Philadelphia. The monthly average premium expressed as a percentage of the cooperative Class I milk price is in the range of 7 percent to 8 percent in the majority of the analyzed cities in the Northeast region.

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[36] "Cwt" is one hundredweight (100 pounds).

[37] The original data used in sections 5.2 and 5.3 are available in the U.S. Department of Agriculture Agricultural Marketing Service Milk Marketing Order Statistics Public Database (USDA AMS 2020). The database reports the announced cooperative Class I milk prices and FMMO minimum Class I milk prices for selected geographic locations. The Class I milk prices reported in the database are monthly prices.

[38] The monthly Class I milk prices and premiums for Atlanta, Georgia, are plotted in Figure A2.2. The teaching note includes figures plotting these prices and premiums for other geographic locations.

[39] Although the length of the pre-antitrust action period in this analysis practically coincides with the length of this period in the analysis of yearly data presented in the previous section, the length of the antitrust action period is shorter (it ends in December 2012, the last year for which announced cooperative Class I milk prices are available).

[40] The monthly Class I milk prices and premiums for Boston, Massachusetts, are plotted in Figure A2.3. The teaching note includes figures plotting these prices and premiums for other geographic locations.

Table 4. U.S. Southeast Region: FMMO Minimum Class I Milk Prices, Announced Cooperative Class I Milk Prices, and Premiums in Selected Markets (2001 to 2012)

City/Price/Premium	Units	Pre-antitrust action period 01/2001 to 07/2008 Average	Antitrust action period 08/2008 to 12/2012 Average	Change in the Average between the two periods (percentage change)
Louisville, KY				
FMMO Class I milk price	$/cwt	16.32	18.25	1.93 (11.8)
Coop Class I milk price	$/cwt	18.17	21.36	3.19 (17.6)
Premium	$/cwt	1.85	3.11	1.26 (68.1)
Premium	percent of Coop price	10.12	14.85	4.73 (46.7)
Memphis, TN				
FMMO Class I milk price	$/cwt	16.92	18.85	1.93 (11.4)
Coop Class I milk price	$/cwt	18.68	22.15	3.47 (18.6)
Premium	$/cwt	1.77	3.30	1.53 (86.4)
Premium	percent of Coop price	9.48	15.20	5.72 (60.3)
Charlotte, NC				
FMMO Class I milk price	$/cwt	17.22	19.35	2.13 (12.4)
Coop Class I milk price	$/cwt	19.16	22.59	3.43 (17.9)
Premium	$/cwt	1.93	3.24	1.31 (67.9)
Premium	percent of Coop price	10.20	14.57	4.37 (42.8)
Atlanta, GA				
FMMO Class I milk price	$/cwt	17.24	19.75	_____(____)
Coop Class I milk price	$/cwt	19.21	23.07	_____(____)
Premium	$/cwt	_____	_____	_____(____)
Premium	percent of Coop price	_____	_____	_____(____)
New Orleans, LA				
FMMO Class I milk price	$/cwt	17.72	19.75	_____(____)
Coop Class I milk price	$/cwt	19.42	22.69	_____(____)
Premium	$/cwt	_____	_____	_____(____)
Premium	percent of Coop price	_____	_____	_____(____)

Data source for prices: USDA AMS (2020).
Note: Students have to perform relevant calculation to record their answer in cells with missing answers (Discussion Question 4.2).

5.3 Retail-Level Effects: Fluid Whole Milk Prices and Farm-to-Retail Margins

The farm-to-retail margin measured in $ per gallon used in the analysis presented in this section is the difference between the retail fluid whole milk price ($ per gallon) and Class I milk price ($ per gallon) reported for a particular geographic location.[41] The Class I milk price can be thought of as a farm price for the purpose of the analysis. The farm-to-retail margin is also calculated as a percentage of the retail fluid whole milk price.[42]

[41] Class I milk prices are reported in $ per cwt. Class I milk prices are converted in $ per gallon to be used in the analysis presented in this section.
[42] Theoretically, the farm-to-retail margin is the sum of the farm-to-wholesale margin and the wholesale-to-retail margin. Wholesale prices of fluid milk products (prices charged by fluid milk processors) are not available for public access. Therefore, it is not possible to calculate the farm-to-wholesale margin and the wholesale-to-retail margin in the fluid milk supply chain.

Table 5. U.S. Northeast Region: FMMO Minimum Class I Milk Prices, Announced Cooperative Class I Milk Prices, and Premiums in Selected Markets (2002 to 2012)

City/Price/Premium	Units	Pre-antitrust action period 01/2002 to 09/2009 Average	Antitrust action period 10/2009 to 12/2012 Average	Change in the Average between the two periods (percentage change)
Boston, MA				
FMMO Class I milk price	$/cwt	17.19	20.24	_____(____)
Coop Class I milk price	$/cwt	18.74	21.85	_____(____)
Premium	$/cwt	_____	_____	_____(____)
Premium	percent of Coop price	_____	_____	_____(____)
Hartford, CT				
FMMO Class I milk price	$/cwt	17.09	20.14	3.05 (17.8)
Coop Class I milk price	$/cwt	18.64	21.75	3.11 (16.7)
Premium	$/cwt	1.55	1.61	0.06 (3.9)
Premium	percent of Coop price	8.57	7.48	-1.09 (-12.7)
Philadelphia, PA				
FMMO Class I milk price	$/cwt	16.99	20.04	_____(____)
Coop Class I milk price	$/cwt	19.19	23.13	_____(____)
Premium	$/cwt	____	____	_____(____)
Premium	percent of Coop price	_____	____	_____(____)
Baltimore, MD				
FMMO Class I milk price	$/cwt	16.94	19.99	3.05 (18.00)
Coop Class I milk price	$/cwt	18.71	21.66	2.95 (15.8)
Premium	$/cwt	1.78	1.67	-0.11 (-6.2)
Premium	percent of Coop price	9.79	7.81	-1.98 (-20.2)
Washington, D.C.				
FMMO Class I milk price	$/cwt	16.94	19.99	3.05 (18.0)
Coop Class I milk price	$/cwt	18.71	21.66	2.95 (15.8)
Premium	$/cwt	1.78	1.67	-0.11 (-6.2)
Premium	percent of Coop price	9.79	7.81	-1.98 (-20.2)

Data source for prices: USDA AMS (2020).
Note: Students have to perform relevant calculations to record their answers in cells with missing answers (Discussion Question 4.2).

5.3.1 Southeast Region: FO5 and FO7 Selected Markets (Table 6) [43]

In the pre-antitrust action period, the monthly average cooperative Class I milk prices are $1.56 per gallon in Louisville, $1.65 per gallon in Atlanta, and $1.67 per gallon in New Orleans. The monthly average retail whole milk prices are $2.88 per gallon in Louisville, $3.35 per gallon in Atlanta, and $3.78 per gallon in New Orleans. The monthly average farm-to-retail margins are $1.31 per gallon in Louisville, $1.70 per gallon in Atlanta, and $2.11 per gallon in New Orleans. The monthly average farm-to-retail margins measured as a percentage of retail prices are approximately 46 percent in Louisville, 51 percent in Atlanta, and 56 percent in New Orleans.

The following changes take place in the antitrust action period, as compared with the pre-antitrust action period. The monthly average cooperative Class I milk prices and the monthly average retail fluid

[43] The monthly prices and farm-to-retail margin for Atlanta, Georgia, are plotted in Figure A2.4. The teaching note includes figures plotting these prices and margin for other geographic locations.

Table 6. U.S. Southeast Region: Announced Cooperative Class I Milk Prices, Retail Fluid Whole Milk Prices, and Farm-to-Retail Margins in Selected Markets (2001 to 2012)

City/Price/Margin	Units	Pre-antitrust action period 01/2001 to 07/2008 Average	Antitrust action period 08/2008 to 12/2012 Average	Change in the Average between the two periods (percentage change)
Atlanta, GA				
Coop Class I milk price	$/gallon	1.65	1.98	0.33 (20.1)
Retail price	$/gallon	3.35	3.42	0.08 (2.3)
Farm-to-retail margin	$/gallon	1.70	1.44	-0.25 (-15.0)
Farm-to-retail margin	percent of retail price	50.92	41.70	-9.22 (-18.1)
Louisville, KY				
Coop Class I milk price	$/gallon	1.56	1.84	0.27 (17.6)
Retail price	$/gallon	2.88	3.06	0.19 (6.5)
Farm-to-retail margin	$/gallon	1.31	1.23	-0.09 (-6.6)
Farm-to-retail margin	percent of retail price	45.96	39.72	-6.24 (-13.6)
New Orleans, LA				
Coop Class I milk price	$/gallon	1.67	1.95	_____(____)
Retail price	$/gallon	3.78	4.33	_____(____)
Farm-to-retail margin	$/gallon	_____	____	_____(____)
Farm-to-retail margin	percent of retail price	_____	____	_____(____)

Data source for prices: USDA AMS (2020).
Note: Students have to perform relevant calculations to record their answers in cells with missing answers (Discussion Question 4.3).

whole milk prices increase in all analyzed cities. The rate of the Class I milk price increase is much higher than the rate of the retail price increase in Atlanta and Louisville. The monthly average farm-to-retail margin measured in $ per gallon decreases in Atlanta and Louisville and increases in New Orleans. The monthly average farm-to-retail margin measured as a percentage of the retail price decreases in all analyzed cities.

In the antitrust action period, the monthly average retail whole milk prices are $3.06 per gallon in Louisville, $3.42 per gallon in Atlanta, and $4.33 per gallon in New Orleans. The monthly average farm-to-retail margins are $1.23 per gallon in Louisville, $1.44 per gallon in Atlanta, and $2.38 per gallon in New Orleans. The monthly average farm-to-retail margins calculated as a percentage of retail prices are approximately 40 percent in Louisville, 42 percent in Atlanta, and 55 percent in New Orleans.

5.3.2 Northeast Region: FO1 Selected Markets (Table 7)[44]

In the pre-antitrust action period, the monthly average cooperative Class I milk prices are $1.60 per gallon in Hartford, $1.61 per gallon in Boston, and $1.65 per gallon in Philadelphia. The monthly average retail fluid whole milk prices are $3.29 per gallon in Boston, $3.30 per gallon in Philadelphia, and $3.38 per gallon in Hartford. The monthly average farm-to-retail margins are $1.65 per gallon in Philadelphia, $1.68 per gallon in Boston, and $1.78 per gallon in Hartford. The monthly average farm-to-retail margins measured as a percentage of retail prices are approximately 50 percent in Philadelphia, 51 percent in Boston, and 53 percent in Hartford.

[44] The monthly prices and farm-to-retail margin for Boston, Massachusetts, are plotted in Figure A2.5. Additional figures plotting these prices and margin for other geographic locations are included in the teaching note.

Table 7. U.S. Northeast Region: Announced Cooperative Class I Milk Prices, Retail Fluid Whole Milk Prices, and Farm-to-Retail Margins in Selected Markets (2002 to 2012)

City/Price/Margin	Units	Pre-antitrust action period 01/2002 to 09/2009 Average	Antitrust action period 10/2009 to 12/2012 Average	Change in the Average between the two periods (percentage change)
Philadelphia, PA				
Coop Class I milk price	$/gallon	1.65	1.99	0.34 (20.5)
Retail price	$/gallon	3.30	3.95	0.65 (19.7)
Farm-to-retail margin	$/gallon	1.65	1.96	0.31 (18.9)
Farm-to-retail margin	percent of retail price	50.92	49.72	-0.57 (-1.1)
Hartford, CT				
Coop Class I milk price	$/gallon	1.60	1.87	0.27 (16.7)
Retail price	$/gallon	3.38	3.67	0.28 (8.4)
Farm-to-retail margin	$/gallon	1.78	1.79	0.02 (1.0)
Farm-to-retail margin	percent of retail price	52.81	49.04	-3.78 (-7.1)
Boston, MA				
Coop Class I milk price	$/gallon	1.61	1.88	_____(____)
Retail price	$/gallon	3.29	3.63	_____(____)
Farm-to-retail margin	$/gallon	_____	____	_____(____)
Farm-to-retail margin	percent of retail price	_____	____	_____(____)

Data source for prices: USDA AMS (2020).
Note: Students have to perform relevant calculations to record their answers in cells with missing answers (Discussion Question 4.3).

The following changes take place in the antitrust action period, as compared with the pre-antitrust action period. The monthly average cooperative Class I milk prices and the monthly average retail whole milk prices increase in all analyzed cities. The rate of the Class I milk price increase is higher than the rate of the retail price increase in Boston and Hartford. Both the monthly average Class I milk price and the monthly average retail price increase by approximately the same rate in Philadelphia.[45] The monthly average farm-to-retail margin measured in $ per gallon increases in all analyzed cities. However, the monthly average farm-to-retail margin measured as a percentage of the retail price decreases in all analyzed cities.

In the antitrust action period, the monthly average retail fluid whole milk prices are $3.63 per gallon in Boston, $3.67 per gallon in Hartford, and $3.95 per gallon in Philadelphia. The monthly average farm-to-retail margins are $1.75 per gallon in Boston, $1.79 per gallon in Hartford, and $1.96 per gallon in Philadelphia. The monthly average farm-to-retail margins calculated as a percentage of retail prices are approximately 48 percent in Boston, 49 percent in Hartford, and 50 percent in Philadelphia.

[45] A somewhat different pattern of milk price behavior in Pennsylvania is due to the effect of the state's milk price control regulation, which affects both the wholesale and retail prices of fluid milk products in Pennsylvania (Novakovic and Washburn 2008; Bolotova and Novakovic 2016). Although FMMOs affect farm-level milk pricing, some states have milk price control regulations affecting retail fluid milk prices (New York) or wholesale and retail fluid milk prices (Pennsylvania) (Bolotova and Novakovic 2012).

5.4 Market and Price Analysis in the Fluid Milk Industry in the Eastern United States: Summary

During the analyzed period (2000 to 2018), the total milk quantity produced tended to decrease in the Southeast (FO5 and FO7) and to increase in the Northeast (FO1). The Class I milk quantity produced tended to decrease in both regions. During the antitrust action period, the Class I milk utilization rate increased in FO7 (Southeast), it practically did not change in FO5 (Appalachian), and it decreased in FO1 (Northeast). Class I milk prices and uniform prices increased over time.

The over-order premiums measured as a percentage of the cooperative Class I milk prices increased in the Southeast region and decreased in the Northeast region (except Philadelphia) in the antitrust action period, as compared with the pre-antitrust action period. In the antitrust action period, the over-order premiums were approximately 15 percent of the cooperative Class I milk prices in the Southeast markets. During the same period the over-order premiums were approximately 8 percent of the cooperative Class I milk prices in the Northeast markets (except Philadelphia). Finally, the number of milk producers (dairy farmers) decreased over time in the analyzed regions.

The rates of Class I milk price increases were higher than the rates of retail fluid whole milk price increases between the pre-antitrust action and antitrust action periods in the majority of the analyzed cities in both the Southeast and Northeast regions. Farm-to-retail margins measured as a percentage of the retail fluid whole milk prices decreased in the antitrust action period in all analyzed cities. The magnitude of the margin decrease was higher in the Southeast markets than in the Northeast markets. In the antitrust action period, farm-to-retail margins were approximately 40 percent of the retail fluid whole milk prices in Atlanta and Louisville (Southeast). Farm-to-retail margins were approximately 50 percent of the retail fluid whole milk prices in Philadelphia, Boston, and Hartford (Northeast).

6 Discussion Questions

The teaching note provides additional guidance for selected discussion questions and suggested answers to all discussion questions.

Set #1 The fluid milk industry structure, structural changes, and competition issues

1.1. Discuss the structural changes that took place in the fluid milk industry in the United States and Eastern United States at the end of the last century and at the beginning of this century. Discuss the largest fluid milk processors, their size, and their market shares as well as the number of fluid milk processing plants they operated. Discuss the number of dairy farmers producing milk in the Southeast and Northeast regions.

1.2. Explain the meaning of the four-firms concentration ratios reported for different stages of the fluid milk supply chain in the United States and Eastern United States. Do these ratios indicate that different participants in the fluid milk industry might exercise market power? Use Figure A2.1 to define market structures in the fluid milk supply chain.

1.3. Discuss the elements of business conduct of Dean Foods and Dairy Farmers of America (DFA) that raised the competition concerns of dairy farmers in the antitrust lawsuits filed in the U.S. Southeast and Northeast regions.

1.4. What is the main difference in the business objectives of Dean Foods (an investor-owned firm) and DFA (a cooperative of dairy farmers)? Explain a competition issue raised by dairy farmers that was related to DFA not performing its main business objective.

1.5. Were the competition concerns raised by dairy farmers during the antitrust litigations related primarily to the buyer market power or the seller market power of fluid milk processors?

Set #2 The theoretical framework explaining buyer and seller market power in the fluid milk processing industry

2.1. Show on a graph two market scenarios for the fluid milk industry explained in this case study: a competitive industry scenario and a market power scenario (show relevant curves, quantities, prices, and marketing margins). The latter scenario should incorporate fluid milk processors' buyer market power in the input (raw milk) market and seller market power in the output (fluid milk products) market. Discuss the effects of fluid milk processors' market power on dairy farmers, retailers, and final consumers (discuss changes in relevant quantities, prices, and marketing margins).

2.2. Dean Foods filed for bankruptcy in fall 2019. DFA acquired most of Dean's assets in spring 2020. DFA is to become the country's largest buyer/marketer/supplier of raw milk used in fluid milk product manufacturing and largest seller of fluid milk products. Extend the graphical analysis presented in Figure 2 to show a new market scenario in which there is one (dominant) fluid milk processor in the industry. Use Figure A2.1 to define the types of market structures in this new market scenario.

Set #3 Data sources

Familiarize yourself with sources of data utilized in the empirical market and price analysis in this case study. Check webpages of the U.S. Department of Agriculture Agricultural Marketing Service Dairy Program Marketing Order Statistics to download selected documents and locate price and quantity data used in the case study. The teaching note provides additional guidance.

Set #4 Empirical market and price analysis in the fluid milk industry in the Eastern United States

4.1. Use data reported in Table 3 to conduct market and price analysis at the dairy farm level for Federal Order 7 "Southeast" (FO7), Federal Order 5 "Appalachian" (FO5), and Federal Order 1 "Northeast" (FO1) during the two periods of interest (the pre-antitrust action period and the antitrust action period). To conduct this analysis: (4.1.1) reproduce calculations of changes in the yearly averages (expressed in physical units and as percentage changes) for the number of milk producers, total milk producer quantity, and uniform price; (4.1.2) calculate changes in the yearly averages (expressed in physical units and as percentage changes) for the Class I milk producer quantity, Class I milk utilization rate, and Class I milk price; and (4.1.3) record your answers in Table 3 and describe the results of your analysis.

4.2. Use data reported in tables 4 and 5 to conduct a price analysis at the dairy farm level for the analyzed FMMOs during the two periods of interest (the pre-antitrust action period and the antitrust action period). To conduct this analysis: (4.2.1) reproduce calculations of the monthly average over-order premiums ("premiums") expressed in $ per hundredweight (cwt) and as a percentage of the cooperative Class I milk prices for the cities for which answers are provided in tables 4 and 5 and (4.2.2) calculate these premiums for the cities for which answers are not provided in these tables; (4.2.3) reproduce calculations of changes in the monthly averages for Class I milk prices and premiums (expressed in physical units and as percentage changes) for the cities for which answers are provided in the last columns of tables 4 and 5 and (4.2.4) calculate these changes for the cities for which answers are not provided in these tables; (4.2.5) record your answers in tables 4 and 5 and describe the results of your analysis.

4.3. Use data reported in tables 6 and 7 to analyze retail fluid whole milk prices and farm-to-retail margins during the two periods of interest (the pre-antitrust action period and the antitrust action period). To conduct this analysis: (4.3.1) reproduce calculations of the monthly average farm-to-retail

margins expressed in $ per gallon and as a percentage of retail prices for the cities for which answers are provided in tables 6 and 7 and (4.3.2) calculate these margins for the cities for which answers are not provided in these tables; (4.3.3) reproduce calculations of changes in the monthly averages for Class I milk prices, retail fluid whole milk prices, and farm-to-retail margins (expressed in physical units and as percentage changes) for the cities for which answers are provided in the last columns of tables 6 and 7 and (4.3.4) calculate these changes for the cities for which answers are not provided in these tables; (4.3.5) record your answers in tables 6 and 7 and describe the results of your analysis.

4.4. Compare the market and price analysis results (tables 3 through 7) for the Northeast region (FO1) and the Southeast region (FO5 and FO7). To complete this analysis, answer the following questions: (4.4.1) Do both regions exhibit similar patterns of changes in the analyzed economic variables during the antitrust action period, as compared with the pre-antitrust action period? (4.4.2) In which city(es)/region(s) and during which period(s) does the empirical evidence on market and price behavior tend to be consistent with a competitive industry scenario? Which economic variables would you use to arrive at your conclusions? (4.4.3) In which city(es)/region(s) and during which period(s) does the empirical evidence on market and price behavior tend to be consistent with a market power scenario? Which economic variables would you use to arrive at your conclusions?

Set #5 Legal issues

5.1. Discuss the reasons that dairy farmers filed class action antitrust lawsuits against DFA and Dean Foods.

5.2. Discuss the purpose of remedies included in the settlement agreements (monetary compensations paid to dairy farmers and some changes in the business conduct of DFA).

About the Authors: Yuliya V. Bolotova is a former Assistant Professor in the Department of Agricultural Sciences at Clemson University (corresponding author: yuliyab@g.clemson.edu).

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Southeast milk antitrust litigation

http://www.southeastdairyclass.com/index.htm

Sweetwater Valley Farm, Inc., et al v. Dean Foods Company et al. (corrected consolidated amended complaint filed on August 04, 2008): http://www.southeastdairyclass.com/PDFs/CorrectedConsolidatedAmendedComplaint.pdf

Dean Foods Company settlement notice (U.S. District Court for the Eastern District of Tennessee; February 14, 2012): http://www.southeastdairyclass.com/PDFs/FINAL percent20- percent20Notice percent20wAtty percent20chgs percent202-21-12.pdf

Settlement agreement between Dean Foods and dairy farmers in the Southeast: http://www.southeastdairyclass.com/PDFs/SettlementAgreement.pdf

Northeast milk antitrust litigation

Allen et al. v. Dairy Farmers of America, Inc. et al. (revised consolidated amended class action complaint and jury demand filed on April 13, 2011): https://www.courtlistener.com/recap/gov.uscourts.vtd.18481.286.0.pdf

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Appendix 1

Section 1 of the Sherman Act makes illegal agreements among competitors aiming to affect market prices, quantities, or both. These agreements are often referred to as cartels or price-fixing cartels or price-fixing conspiracies. Section 2 of the Sherman Act makes illegal conduct by a single firm and conspiracy by a group of firms aiming to attempt to monopolize or to monopolize the market, conduct that often affects market prices, quantities, or both. The Clayton Act (1914) allows private parties (individuals and firms) to recover treble damages and reasonable attorney fees for violations of the Sherman Act.

The Capper-Volstead Act (1922) is limited antitrust immunity for collective agricultural marketing activities of agricultural producers from the Sherman Act (assuming these activities are implemented through properly formed organizations). The Capper-Volstead Act immunity allows dairy cooperatives to negotiate with milk processors over-order premiums paid for milk and other terms of trade. According to the case law interpreting the Capper-Volstead Act, any attempt of a cooperative to engage in predatory (anticompetitive) conduct to attempt to monopolize or to monopolize the market or to combine (to conspire) with other entities (cooperatives and non-cooperatives) to attempt to monopolize or to monopolize the market is outside Capper-Volstead Act immunity (Frederick 1989).

Appendix 2

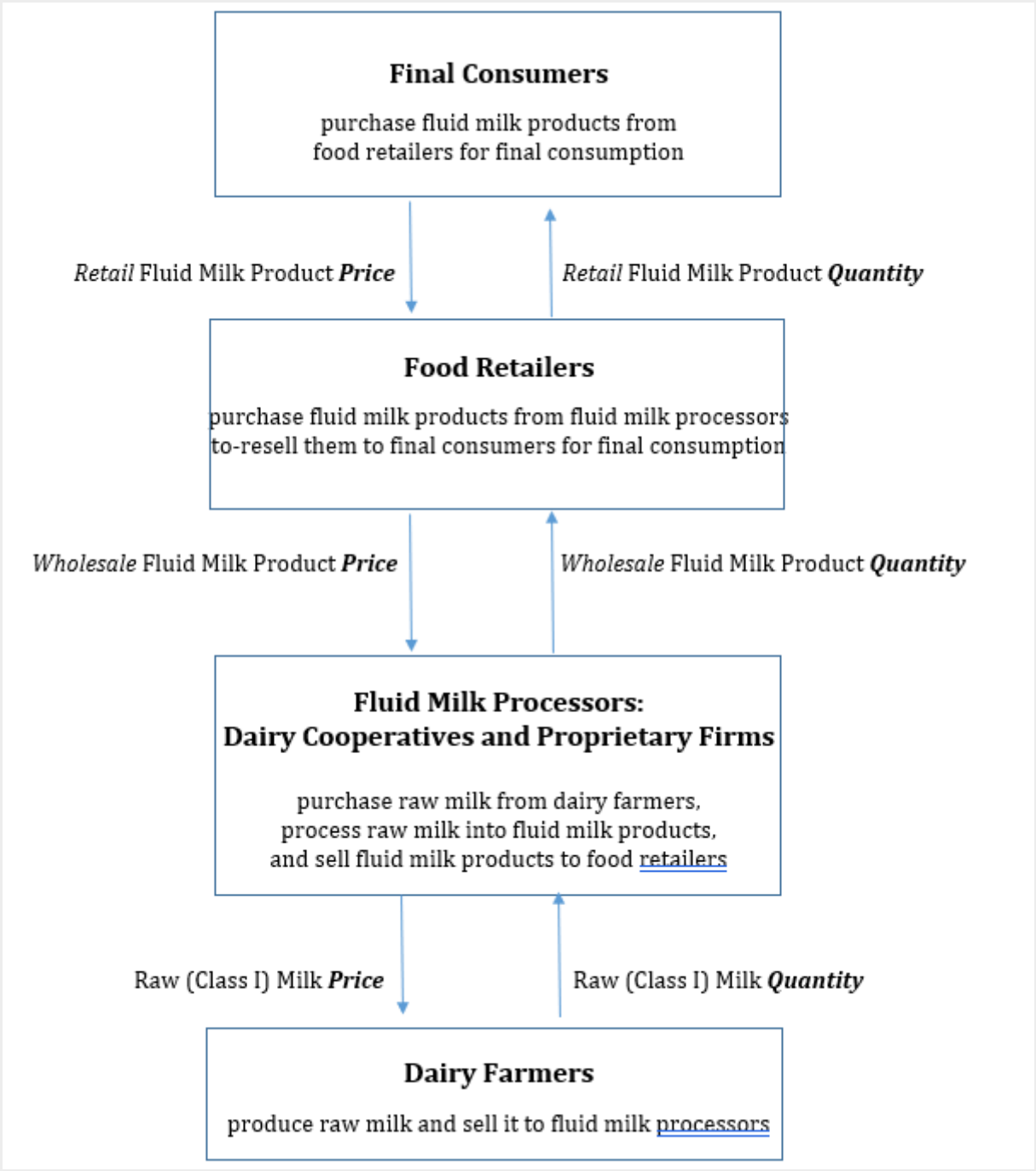

Figure A2.1. Fluid Milk Supply Chain Structure

Note: Dairy cooperatives do not "purchase" milk from dairy farmers. Dairy cooperatives process and market milk on behalf of dairy farmers.

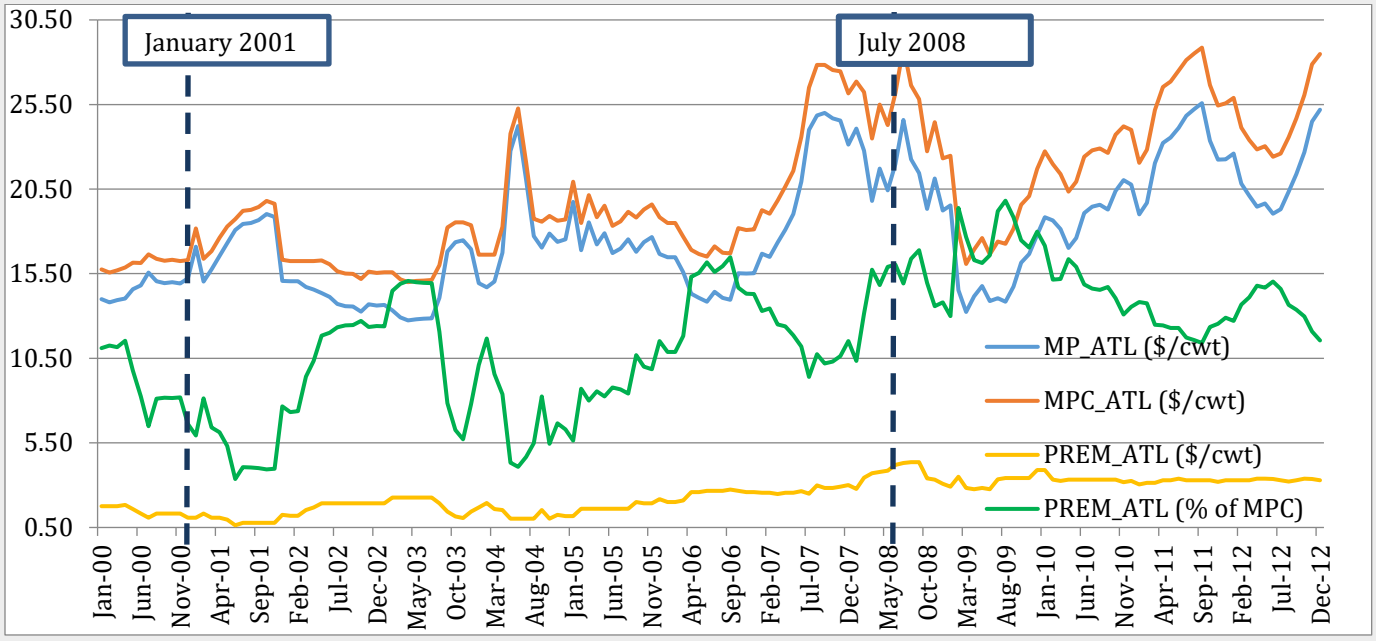

Figure A2.2. Atlanta, Georgia: FMMO Minimum Class I Milk Price (MP), Announced Cooperative Class I Milk Price (MPC), and Premium (PREM) (2000-2012).

Data source for prices: USDA AMS (2020). The premium is calculated by the author.
Note: The pre-antitrust action period is January 2001 to July 2008, and the antitrust action period is August 2008 to December 2012.

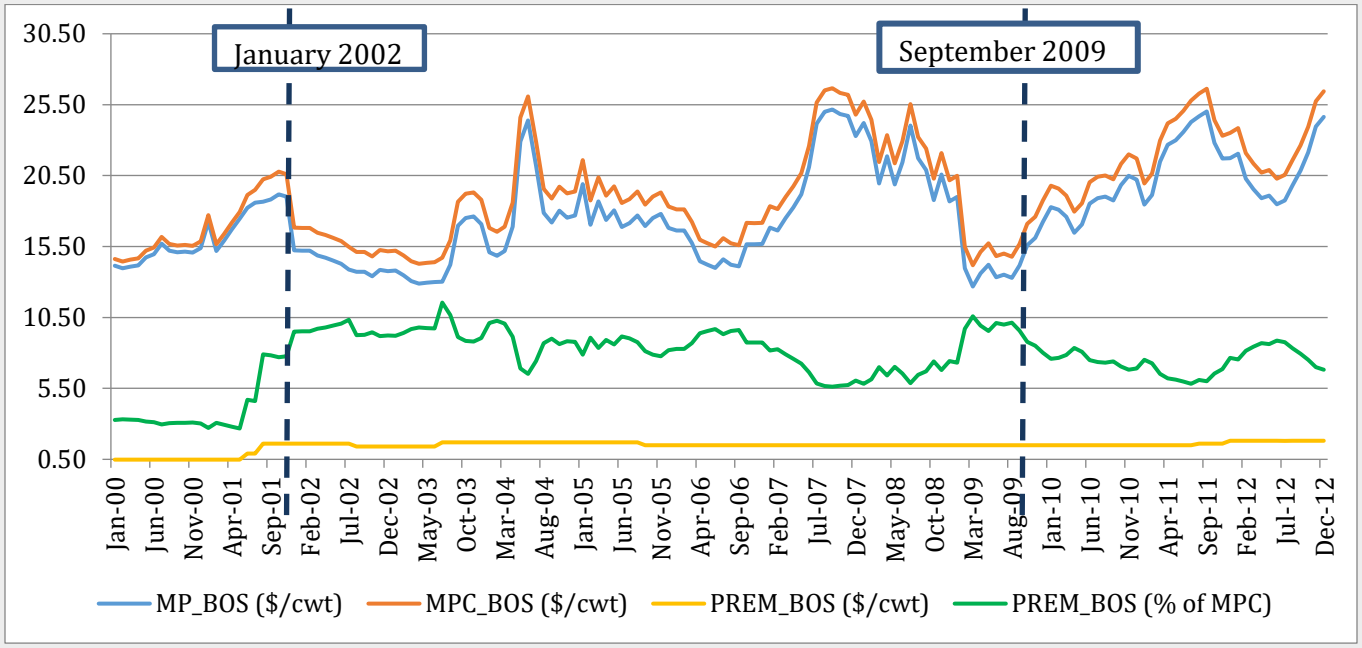

Figure A2.3. Boston, Massachusetts: FMMO Minimum Class I Milk Price (MP), Announced Cooperative Class I Milk Price (MPC), and Premium (PREM) (2000-2012).

Data source for prices: USDA AMS (2020). The premium is calculated by the author.
Note: The pre-antitrust action period is January 2002 to September 2009, and the antitrust action period is October 2009 to December 2012.

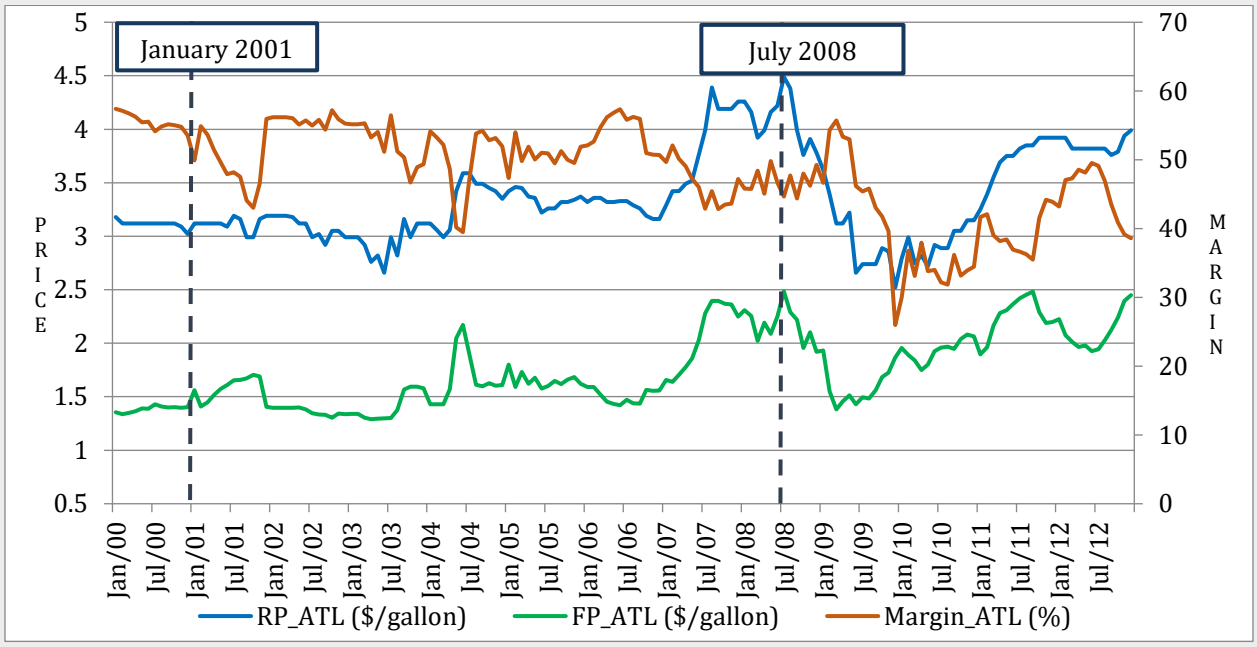

Figure A2.4. Atlanta, Georgia: Retail Fluid Whole Milk Price (RP), Announced Cooperative Class I Milk Price (FP), and Farm-to-Retail Margin (Margin) (2000-2012).

Data source for prices: USDA AMS (2020). The margin is calculated by the author.
Note: The pre-antitrust action period is January 2001 to July 2008, and the antitrust action period is August 2008 to December 2012.

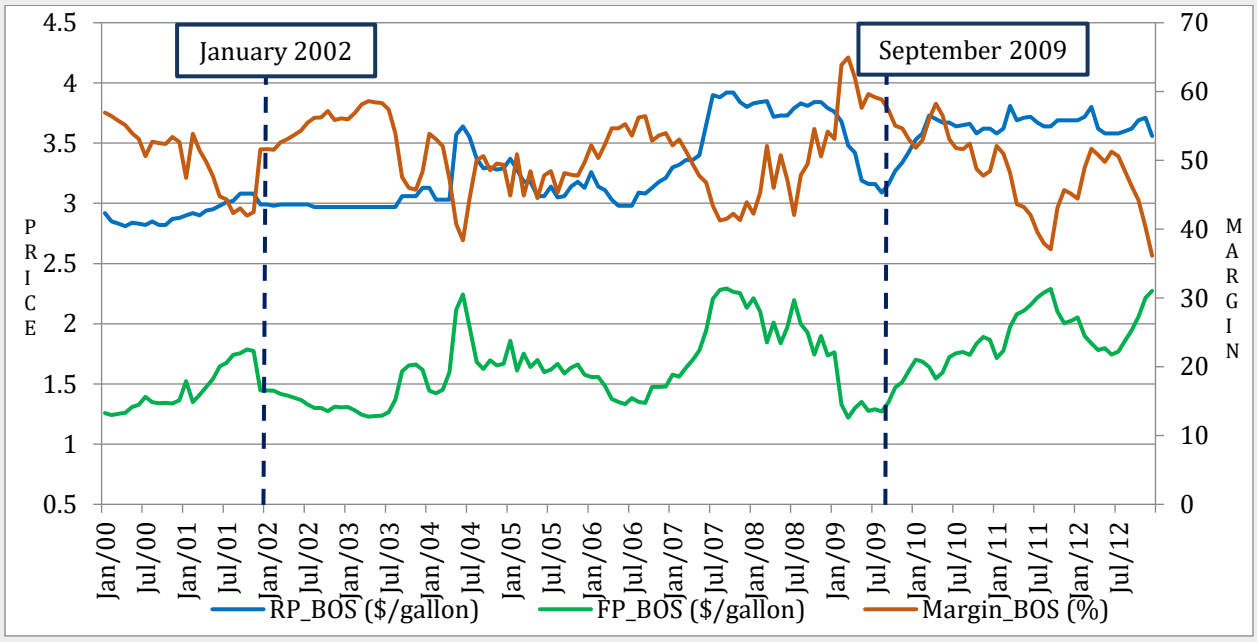

Figure A2.5. Boston, Massachusetts: Retail Fluid Whole Milk Price (RP), Announced Cooperative Class I Milk Price (FP), and Farm-to-Retail Margin (Margin) (2000-2012).

Data source for prices: USDA AMS (2020). The margin is calculated by the author.
Note: The pre-antitrust action period is January 2002 to September 2009, and the antitrust action period is October 2009 to December 2012.