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Contents

Applied Economics Teaching Resources

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Research Article

Who Fills the Seats? Offering Extra Credit and Instructor Perceptions of Who Will Attend

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Abstract
Past research on the effectiveness and fairness of offering extra credit opportunities to students has been mixed. This paper contributes to this ongoing literature in two ways. First, we develop a student effort model that investigates how student utility, study time, productivity, and knowledge change when faculty offer extra credit opportunities. Second, we employ a survey of 251 college instructors from across the United States to examine instructor perceptions of which students attend extra credit events and at what point in the semester students are more likely to attend.

1 Introduction

Many economics instructors use a variety of strategies to enhance their courses, such as inviting distinguished economics speakers to campus. To encourage participation, these instructors sometimes offer extra credit to encourage students to attend these opportunities. The present paper examines instructor perceptions about which students will take advantage of extra credit or similar opportunities. A student effort model is used to investigate how a student's study time, knowledge, and leisure change when extra credit events are offered. The model suggests a positive correlation between knowledge, grade, and the incremental utility from an extra credit opportunity.

A panel of 251 college instructors from across the United States completed a Qualtrics survey to investigate instructor perceptions, including which students will attend extra credit events and when during the semester they will be more likely to attend. We use the results of this survey to investigate the educational factors that influence instructor beliefs about student behavior regarding extra credit activities. These empirical results align with our effort model, suggesting that differences in student behavior are based on student motivations.

This paper proceeds with a literature review, presents a simple model of student effort, examines instructor perceptions of students who will likely attend extra credit events, and ends with instructor perceptions of when during the semester students are more likely to attend such events. This analysis could apply equally well to extra credit opportunities besides speakers, and we briefly look at an additional extra credit example, but for purposes of efficient exposition we stick with the speaker example through most of the paper.

2 Literature Review

The pedagogical practice of offering extra credit in higher education appears to be a somewhat controversial and an unsettled issue in the academic literature. Several authors across academic disciplines have found theoretical and empirical justification for both dismissing and supporting the practice of offering extra credit. For example, Faud and Jones (2012) found that extra credit in upper-level computer science courses motivated student effort, improved grades and learning, and potentially lowered mental pressures. This positive viewpoint suggests that extra credit can motivate students to work harder, can allow students to explore course topics in greater detail, and can be used if the student has a serious illness or problem. Felker and Chen (2020) examined extra credit to encourage the effort and work distribution by students to reduce procrastination and found that it was effective. On the other hand, Norcross, Horrocks, and Stevenson (1989) and Weimer (2011) discussed several factors as to why professors do not provide extra credit opportunities to their students including the belief that it discourages responsible student attitudes, the unfairness associated of offering it to select students (e.g., those students with poor performance), and the impracticality of giving additional work to those students who have trouble with basic course material. Wilson (2002) suggested extra credit promotes moral hazard stating, “The existence, or the hope of extra credit may induce students to prepare less carefully for exams and papers with the expectation that additional points can be earned on future assignments” (p. 97).

It is not surprising that without academic consensus on exactly how the use of extra credit assignments (ECAs) and different ECA types translate into student knowledge, participation, and utility, many instructors find themselves spending a great deal of time on constructing exercises that have uncertain outcomes (Hill, Palladino, and Eison 1993). Haber and Sarkar (2017) suggest that instructors “spend significant amount of time designing, administering, and grading ECAs without sufficient and precise knowledge of how this effort justifies the learning outcome or if it does so at all. Faculty today predominately rely on their intuitive knowledge and scant scientific evidence for designing and administering ECAs for their courses” (p. 291). Key characteristics for instructors employing extra credit include the desire to see students succeed and improve their work ethic. The present paper might be thought of as a contribution to this literature as flexibility in grading via extra credit allows more degrees of freedom for students trying to turn effort into a grade.

Extra credit offers one type of flexibility in grading. Other forms include allowing retakes of exams or rewriting of papers. Michaelis and Schwanebeck (2016) developed an expected utility model that allows variation in testing arrangements and rules. While the authors failed to conclude that offering retakes improve utility, they do find that student effort can be affected by second exam policies. Paredes (2017) examined the effect of relative and absolute grading systems on student effort. The author applied a model where students maximized their utility by choosing effort. Brustin and Chavkin (1997) ran an experiment on grading systems and law school student effort. The authors found evidence that student participation and preparedness increased for a majority of students in clinical courses when grades were assigned to those classes. In a limited sample, Mays and Bower (2005) provided extra credit opportunities to 40 engineering students over the course of a semester. Interesting findings included the fact that more ECAs were attempted after midterm grades were posted (e.g., second half of the semester), and students thought the extra credit was fair and helped their final grades. In addition, other activities that students were involved in such as work and leisure deterred from their participation in the ECAs. Dalakas and Stewart (2020) determined that instructors should frame extra credit opportunities as a loss of an opportunity as opposed to gaining one in order to motivate students in participating in the extra credit opportunity.

As far as we are aware, the treatment of how uncertainty affects student effort on extra credit events is unique to the present paper, but our model below otherwise has similarities to that of Allgood, Walstad, and Siegfried (2015) and Lewer, Corbett, Marcum, and Highfill (2021). These studies found that standard student effort models of expected utility are often based on knowledge, grades, and leisure, but relatively few studies allowed for uncertainty. Oettinger (2002) has a model of student effort where the relationship between study effort and course grade was subject to a random shock. He found empirical evidence that students cluster around the bottom boundaries of letter grades and that students near bottom grade boundaries had stronger performances on final exam scores. Foltz, Clements, Fallon, and Stinson (2021) surveyed undergraduate students and found that most students are motivated to attend academic related speaker events based on receiving extra credit. Finally, Gneezy et al. (2019) used an experimental approach to test international differences in student effort in response to certain incentive programs. They found that U.S. students improved their scores on standardized tests in response to incentives, while Chinese students did not.

3 Student Effort Model

Suppose student effort is not subject to diminishing returns and produces knowledge K, an abstract or latent measure of the level of learning that indirectly translates to grades:

$$K = \alpha X + \beta S + \gamma XS \tag{1}$$

where $\alpha > 0$, $\beta > 0$, and $\gamma \geq 0$ with $\alpha > \beta$ when $\gamma = 0$. Regular study effort S produces knowledge at a rate measured by β; X, the time spent on extra credit, produces knowledge at a rate of α. There may also be an interaction term so that time spent on extra credit activities actually makes regular study time more productive, at a rate measured by γ. The student can choose to not participate in the extra credit activity in which case $X = 0$; if they choose to participate, the value of X is set by the instructor and the student takes it as a parameter. In this model, we assume the instructor creates specific extra credit opportunities that take a certain amount of time, such as attending events, and students have the discrete choice whether to complete the opportunity or not. Note that students will only spend time on extra credit if it is more productive than regular studying, thus the assumption that $\alpha > \beta$; otherwise, they would just stay home and study instead of attending the event.

Study effort produces knowledge with certainty, but there is uncertainty about how knowledge is reflected in the total points earned in the course, λ. To keep things as simple as possible, the instructor decides between the "default" grade and a "higher" grade based on the point total at the end of the semester. Suppose that a given knowledge level K can result in a range of possible point totals, with the number of points being uniformly distributed on the exogenous range $2R$ centered on K, that is on the range $(K - R, K + R)$ with a pdf of ½R. The "probability of the higher grade" is:

$$PHG = \Pr(K \geq C) = \int_C^{K+R} \frac{1}{2R}\, d\lambda\ = \frac{K + R - C}{2R} = \frac{1}{2R}(\alpha X + \beta S + \gamma XS + R - C) \tag{2}$$

where C is the grade cutoff. For a very simple example, suppose study effort S is 100 and $\beta = 1.2$ (and no extra credit), so that knowledge K is 120. If $R = 30$ and the cutoff for the higher grade is $C = 145$, then $PHG = \frac{120+30-145}{60} = .0833$ so there is an 8.33 percent probability of the student getting the higher grade.

The student has a time endowment N and time not spent on studying is "leisure" (L), so that:

$$L = N - X - S\,. \tag{3}$$

Assume $\beta N - C \geq 0$, that is, a student who spends all their time endowment studying will at least achieve the cutoff for the higher grade.

The student chooses S to maximize utility, which is a function of the probability of the higher grade, knowledge, and leisure:

$$U = g\log(1 + PHG) + h\log(K) + j\log(L) \tag{4}$$

subject to equations (1)–(3), and noticing that one is added to the probability because a log utility function is assumed. Without loss of generality, assume $g \geq 1$, $h \geq 1$, and $j \geq 1$.

Conceptually, the student chooses study effort, S, but it will be algebraically convenient to change variables and rewrite the optimization problem in terms of knowledge K. From equation (2):

$$1 + PHG = \frac{2R + K + R - C}{2R} = \frac{K - Z}{2R}, \tag{5}$$

where the composite parameter $Z = C - 3R$ for algebraic convenience, captures the grading parameters. From equation (1):

$$S = \frac{(K - \alpha X)}{(\beta + \gamma X)}. \tag{6}$$

Plugging equation (6) into equation (3):

$$L = \frac{(\beta + \gamma X)(N - X) + \alpha X - K}{(\beta + \gamma X)} = \frac{M(X) - K}{(\beta + \gamma X)} \tag{7}$$

where

$$M(X) = (\beta + \gamma X)(N - X) + \alpha X = \beta N + (\alpha - \beta)X + \gamma XN - \gamma X^2. \tag{8}$$

Looking at the right-hand side of the composite parameter $M(X)$, the first term of the right-hand side is the knowledge output if the entire time endowment were spent on regular study; the next term captures the positive increment for time spent on extra credit. The final two terms capture the interaction effect, which will be discussed later, but notice that X has both a positive effect and negative effect on $M(X)$ when $\gamma > 0$. Intuitively, $M(X)$ represents total knowledge available to the student from their time endowment if they do nothing but study.

The first order condition (assuming an interior solution) of equation (4) with respect to knowledge is thus:

$$\frac{g}{K - Z} + \frac{h}{K} - \frac{j}{M(X) - K} = 0. \tag{9}$$

The full model will be examined shortly, but a couple of special cases may aid intuition. Suppose a student is motivated by the probability of a higher grade rather than by knowledge. That is, suppose $h = 0$ in equations (4) and (9). The optimal knowledge is:

$$K = \frac{jZ + gM(X)}{g + j} = \frac{j(C - 3R) + g(\beta N + (\alpha - \beta)X + \gamma XN - \gamma X^2)}{g + j} \tag{10}$$

and the optimal study time is:

$$S = \frac{jZ + gM(X) - \alpha(g + j)X}{(g + j)(\beta + \gamma X)} = \frac{j(C - 3R) + g(\beta N + (\alpha - \beta)X + \gamma XN - \gamma X^2) - \alpha(g + j)X}{(g + j)(\beta + \gamma X)}.$$

For a second special case, suppose a student is motivated by knowledge rather than grades. That is, suppose $g = 0$ in equations (4) and (9). Knowledge is:

$$K = \frac{h\,M(X)}{h + j} = \frac{h\,(\beta N + (\alpha - \beta)X + \gamma XN - \gamma X^2)}{h + j} \tag{11}$$

and study effort is:

$$S = \frac{hM(X) - \alpha(h+j)X}{(h+j)(h(\beta+\gamma X)} = \frac{h(\beta N + (\alpha-\beta)X + \gamma XN - \gamma X^2) - \alpha(h+j)X}{(h+j)(h(\beta+\gamma X)}.$$

The first special case for a grade-motivated student illuminates the instructor choices with regard to the grading variables. Notice first from equation (10) that an increase in the grade cutoff increases knowledge. From equation (2), holding knowledge constant, an increase in the grade cutoff reduces the probability of the higher grade, and the question arises of whether a student will study less if you raise the grade cutoff for an A from, say, 89 to 90. These results suggest that in fact a grade-motivated student will respond by studying more. There is an argument here that instructors should think quite hard about grade cutoffs, and perhaps raise them, while keeping in mind their specific situation, and the mores and standard practices of their department and institution.

The grading parameter R, which measures the range of grades a given level of effort might result in, is perhaps less in the control of the instructor. But they might be able to influence it, including for example by changing their system for assigning partial credit, or how they treat missed questions. From equation (2), with study effort held constant, a reduction in R increases the probability of a higher grade when $K > C$ and decreases it when $K < C$, and therefore from equation (10), reducing R increases the student's optimal study effort and knowledge.

Comparing the two special cases, notice that if the weights in the utility functions are all equal to one, knowledge for the grade-motivated student is greater than for the knowledge-motivated student (subtract equation (11) from equation (10)). More plausibly, if the weights differ between the two special cases, comparing knowledge depends on those weights.

Turning to the full model now, the first order condition (9), after multiplying by denominators and rearranging, is equivalent to the quadratic equation:

$$(g+h+j)K^2 - \big((j+h)Z + (g+h)M(X)\big)K + hZM(X) = 0$$

and therefore, using the quadratic formula:

$$K = \frac{(j+h)Z + (g+h)M(X) + \sqrt{T}}{2(g+h+j)}, \tag{12}$$

where the constant T (for algebraic convenience) is:

$$T = \big((j+h)Z + (g+h)M(X)\big)^2 - 4(g+h+j)hZM \tag{13}$$

and noting that the larger root is required for an interior solution.

Our goal is to look at the comparative statics with respect to X, the extra credit variable. To that end it will be algebraically convenient to first find the effect of a change in $M(X)$ on knowledge. Although the calculations will be omitted for brevity, it can be shown that

$$\frac{d\sqrt{T}}{dM(X)} = \frac{(g+h)\sqrt{T - 4ghj\,(g+h+j)Z^2}}{\sqrt{T}} > 0 \tag{14}$$

which implies $\frac{dK}{dM(X)} > 0$ from equations (12) to (14). Notice that from condition (5), the probability of a higher grade is a linear function of knowledge, so this implies that $\frac{dPHG}{dM(X)} > 0$ as well.

The optimal leisure is found by substituting equation (12) into equation (7). To investigate how $M(X)$ affects leisure it will be convenient to first look at $(\beta + \gamma X)L$, which we will call the knowledge cost of leisure, denoted by KCL. That is, it is the amount of knowledge that the time spent on leisure could have created. Looking at equation (7) again, $K + KCL = M(X)$ (that is, actual knowledge plus knowledge cost of leisure equals total available knowledge). We use equation (7) and equation (12) to write:

$$KCL = (\beta + \gamma X)L = \frac{(g+h+2j)M(X) - (g+h)Z - \sqrt{T}}{2(g+h+j)} \ . \tag{15}$$

As above, the ultimate goal is to do comparative statics with respect to X, the extra credit parameter, but the strategy is again to first look at the comparative statics of $M(X)$. Differentiating equation (15), we find:

$$\frac{dKCL}{dM(X)} = \frac{(g+h+2j) - \frac{d\sqrt{T}}{dM}}{2(g+h+j)}. \tag{16}$$

To prove that $\frac{dKCL}{dM(X)} > 0$ in equation (16), we assume that the numerator is positive, and show that that assumption leads to a necessarily true inequality. That assumption is the equivalent of:

$$(g+h+2j) > \frac{d\sqrt{T}}{dM}.$$

We then substitute equation (14) into the numerator of equation (16):

$$(g+h+2j) > \frac{(g+h)\sqrt{T - 4ghj\,(g+h+j)Z^2}}{\sqrt{T}}.$$

Squaring both sides:

$$(g+h+2j)^2 > \frac{(g+h)^2(\,T - 4ghj\,(g+h+j)Z^2)}{T}.$$

Solving for T:

$$\left(\frac{(g+h+2j)^2}{(g+h)^2} - 1\right)T > -4ghj\,(g+h+j)Z^2.$$

This inequality is necessarily true because the left-hand side is positive while the right-hand side is negative. And because all of our previous steps were reversible, it necessarily implies that our original assumption of $\frac{dKCL}{dM(X)} > 0$ is true.

The arguments of the student utility are now characterized in terms of Z, the parameter capturing the grading parameters, and $M(X)$, the parameter derived from the time constraint. We can now explore the effects of the instructor's choices about the type and scale of the extra credit opportunity on student knowledge, leisure, and utility. We will focus on the differences between students in the next section. Formally, this will be done by looking at:

$$\frac{dK}{dX} = \frac{dK}{dM(X)}\frac{dM(X)}{dX} \quad \text{and} \quad \frac{dKCL}{dX} = \frac{dKCL}{dM(X)}\frac{dM(X)}{dX}$$

and the implications of these relationships. It has been shown that both $\frac{dK}{dM(X)} > 0$ and $\frac{dKCL}{dM(X)} > 0$. Therefore, the sign of $\frac{dK}{dX}$ and $\frac{dKCL}{dX}$ depends on the sign of $\frac{dM(X)}{dX}$. From equation (8):

$$\frac{dM(X)}{dX} = (\alpha - \beta) + \gamma N - 2\gamma X \ . \tag{17}$$

The implications for the instructor's choice of the size of X depend on the interaction effect in the knowledge production function (1). Suppose first that $\gamma = 0$. In this case $\frac{dM(X)}{dX} > 0$ and so a larger X always increases knowledge and the probability of a higher grade. Noting that $L = \frac{KCL}{\beta}$ in this case, $\frac{dM(X)}{dX} > 0$ also implies $\frac{dKCL}{dX} > 0$ and $\frac{dL}{dX} > 0$. The increases in knowledge, the probability of a higher grade, and leisure ensure that utility is increasing. Total study time, the sum of $S + X$, is decreasing because leisure is increasing. When it comes to extra credit, from the student's point of view, the more the better. Table 1 gives a numerical example.

Table 1. Example Outcomes when $\gamma = 0$

X	K	PHG	L	S	$S + X$	U
0	150	0.21	52.75	147.25	147.25	9.17
100	170	0.5	63.24	36.76	136.76	9.69

C = 170, R = 34.5795, N = 200, α =1.3256, β = 1.0187, $g = h = j = 1$, and $\gamma = 0$

The considerations for the instructor's choice of X when $\gamma > 0$ are more complicated but still essentially driven by $M(X)$. From equation (17), this function is maximized when the value of the extra credit variable is:

$$X_{KMax} = \frac{(\alpha - \beta) - \gamma N}{2\gamma} \ . \tag{18}$$

The notation reflects the observation that maximizing $M(X)$ is equivalent to maximizing knowledge, and thus the probability of a higher grade (i.e., $\frac{dK}{dX} = 0$ if and only if $\frac{dM(X)}{dX} = 0$). Below this value, increasing X increases knowledge, the probability of a higher grade, and the knowledge cost of leisure. Whether this change increases leisure (or utility) depends on the relative size of the parameters in $M(X)$. But in the neighborhood of X_{Kmax}, the effect on leisure can be signed; it is negative. To see this, recall $\frac{dM(X)}{dX} = 0$ implies $\frac{dKCL}{dM} = 0$ so that from the definition of KCL

$$\frac{dL}{dX} = -\frac{\gamma L}{(\beta + \gamma X)} < 0 \, .$$

This implies that for values of X that are close to the one that maximizes knowledge X_{Kmax}, an increase in extra credit decreases leisure. The extra credit level that maximizes knowledge most definitely does not maximize student utility, and since leisure is falling in that neighborhood, the level of extra credit that maximizes utility is less than the one that maximizes knowledge.

In some cases, the type and scale of an extra credit project are not completely within the control of the instructor. Some projects are "chunky" and may require a time commitment above X_{Kmax}. The question might be whether the knowledge a student gets from the project is greater than that of no extra credit at all (i.e., $X = 0$) even though it is less than the maximum knowledge attainable. Looking at the definition of $M(X)$ in equation (8) again

$$X_{K0} = \frac{(\alpha - \beta) - \gamma N}{\gamma} \, . \tag{19}$$

The notation here reflects the fact that when X reaches X_{K0}, knowledge has declined back to the level of no extra credit whatsoever. Notice $X_{K0} = 2X_{Kmax}$. An example is given in Table 2.

Table 2. Example Outcomes when $\gamma > 0$

X	K	PHG	L	S	$S + X$	U
0	150	0.21	52.75	147.25	147.25	9.17
56	169.23	0.49	49.29	94.71	150.71	9.43
X_{Kmax} = 80.68	171.22	0.52	45.76	73.56	154.24	9.38
100	170	0.50	42.42	57.58	157.58	9.29
116	167.14	0.46	39.35	44.65	160.65	9.17
X_{K0} = 161.36	150	0.21	29.44	9.20	170.56	8.58

C = 170, R = 34.5795, N = 200, α =0.8255, β = 1.0187, $g = h = j = 1$, and $\gamma = 0.005$

Notice that the α in Table 2 is calibrated to give the same values for K between Table 1 and Table 2 both when $X = 0$ and $X = 100$ (where $K = 150$ and $K = 170$, respectively). Without an interaction term, α must be greater than β for anyone to attend an extra credit event. With the interaction term though, the direct effect of the extra credit event on knowledge α can be less than that for regular study time measured by β as long as the indirect effect γ is large enough. (Because of scale issues, γ is very small compared to α or β.)

An instructor thinking about the best or optimal X to choose from options in Table 2 might pick X_{Kmax} = 80.68 because it maximizes knowledge. The student would do the extra credit because utility is greater than that of $X = 0$, and for the student it is a binary decision—they either do the extra credit or not. But they would prefer a smaller project; here student utility is maximized when $X = 56$. For simplicity, integer values of X are used except for the solutions to equations (18) and (19). An instructor with complete control of X would never choose a project larger than 80.68 and might well choose a smaller one to be sensitive to student concerns. But if projects are "chunky" in their time requirements they might assign a project up to $X = 116$, where students are indifferent between doing the assignment and not completing it.

One implicit assumption that has been made is that the variable X captures all the cost considerations of the extra credit. But some types of extra credit may have higher opportunity costs than others, and the cost may differ between students. For a simple example, consider an extra credit event not during class time for a student with a child. Suppose the student needs to trade childcare with a neighbor to be able to attend the extra credit event. In that case the time constraint would be:

$$L = N - \theta X - S \tag{20}$$

where $\theta \geq 1$. For example, if the student had to spend the same amount of time watching the neighbor's child as the neighbor spent watching the student's child, then $\theta = 2$, so the extra credit event costs this student more time than a student without a conflict. A similar argument could be made for a student with a class conflict for the extra credit event; they might have to devote time to make up the missed class.

From equations (20) and (7), leisure is now:

$$L = \frac{(\beta + \gamma X)(N - \theta X) + \alpha X - K}{(\beta + \gamma X)} = \frac{M(X) - K}{(\beta + \gamma X)} \tag{21}$$

where

$$M(X) = \beta N + (\alpha - \theta\beta)X + \gamma XN - \theta\gamma X^2 \tag{22}$$

abusing the notation slightly or thinking of the definition of M in equation (8) as the special case of equation (22) when $\theta = 1$.

The formal results above hold for this extension of the model, because $\frac{dM(X)}{d\theta} < 0$, and all of the results that depend on $M(X)$ are qualitatively similar but smaller. An increase in θ decreases knowledge, the probability of a higher grade, leisure, and utility. Note as well that equations (18) and (19) are now:

$$X_{KMax} = \frac{(\alpha - \beta) - \gamma\theta N}{2\gamma\theta} \text{ , and}$$

$$X_{K0} = \frac{(\alpha - \beta) - \gamma\theta N}{\gamma\theta} \text{ .}$$

Clearly an increase in θ makes the extra credit project more costly in terms of time and reduces both the knowledge maximizing level of X, and what we might think of as the hard upper bound on X.

Table 3 extends the example of Table 2 to the case where θ is greater than one. The knowledge maximizing value of X here has fallen to 64.08 from 80.68 in Table 2. The utility maximizing X here has fallen to 42 from 56 in Table 2. And for a given value of X, set at 100 in the examples, the utility here is 9.04, which is less than that for $X = 0$, so the student would not do this project. In Table 2 where $\theta = 1$ when $X = 100$ the utility is 9.29, which is greater than that for no extra credit at all, so the student would choose to do it.

How much control an instructor has over extra credit opportunities depends on many factors of course. If an instructor could create an extra credit project without the extra time requirement implied by $\theta > 1$ that met the same pedagogical goals, they might strongly consider doing so to help students with childcare issues or long commutes. If that is not possible, then the smaller the scale of the project, the more likely it is that it would benefit all students.

Table 3. Example Outcomes when $\gamma > 0$ and $\theta > 1$

X	K	PHG	L	S	$S+X$	U
0	150	0.21	52.75	147.25	147.25	9.17
42	162.96	0.40	49.39	104.41	146.41	9.33
X_{Kmax} = 64.08	164.71	0.42	46.01	83.49	147.58	9.29
85	163.14	0.40	42.10	64.40	149.40	9.17
100	160.08	0.36	38.95	51.05	151.05	9.04
X_{K0} = 128.17	150	0.21	32.38	26.63	154.05	8.68

C = 170, R = 34.5795, N = 200, α =1.3256, β = 0.8255, $g = h = j = 1$, $\gamma = 0.005$, and θ = 1.1

4 Survey

We commissioned a Qualtrics panel of 251 college instructors from across the United States. The panel had no restrictions on age for adults, gender, academic field, or other demographics; participants were only required to teach in higher education and use exams for grading. Participants were compensated for completing the survey, which took about 15 minutes to finish. The survey asked about demographics and academic background, instructor policies, beliefs about students, and whether those beliefs shape teaching policies such as offering extra credit opportunities and instructor perceptions on who would complete extra credit opportunities. Table 4 shows the demographics and relevant background of survey respondents that will be used for future regressions.

Instructors were asked about their perceptions of student motivations, given three possible motivations and "other." They were asked to rank those motivations in order of importance to students and give percentages of students with that as their primary motivation (Table 5).

A simple model such as the one developed obviously misses many important aspects of student motivations and behavior. Allowing for the considerable simplification of theory, we have modeled grade-motivated students and knowledge-motivated students. Career-motivated students are perhaps best described by the full model. Instructors in the sample clearly saw students as being motivated by earning a grade, while learning for future career goals or job skills was also an important student motivation. Knowledge and understanding for personal satisfaction get a respectable showing, but not quite as much as the collective category of other motivations. Of course, professor perceptions of student motivations may be incomplete or incorrect, but professors do not have complete information about their students and must design their course on their best estimate of student motivations and responses.

Student behavior is sometimes complex. But as long as student behavior is informed by time decisions such as trading off leisure and course effort, we would argue that students with all three motivations will react in qualitatively similar ways to an extra credit opportunity. Perhaps not surprisingly given that consistency, the primary empirical results to be discussed below do not vary much with differences in instructor perceptions of students' motivations, with one exception for when during the semester students are more likely to attend an event. We will return to the latter below.

Table 4. Demographics and Background (*n* = 251)

Variable	Level	Frequency
Gender	Female	65.74%
	Male	33.86%
	Other	0.40%
Age	18–30	9.16%
	31–40	29.88%
	41–50	22.31%
	51–60	21.12%
	61–70	13.94%
	71+	3.59%
Teaching Experience	1–3 years	7.17%
	4–7 years	22.71%
	7–12 years	25.10%
	13–20 years	19.52%
	21–30 years	16.73%
	30+ years	8.76%
Course Format	Face to Face	79.28%
	Hybrid	9.56%
	Online	11.16%
Position	Ranked Professor	39.44%
	Full-Time Instructor	30.68%
	Part-Time Instructor	29.88%
Academic Field	Business/Agri. Business	9.96%
	Engineer	3.19%
	Humanities	27.09%
	Natural Science	23.51%
	Social Science	25.10%
	Pre-Professional	9.16%
	Tech	1.99%
Grade Flexibility:	Helps Overall	79.68%
	Hurts Overall	20.32%
Same-credit Makeups for Sleeping in	Yes	35.86%
	No	64.14%

Offering extra credit events requires considerable effort on the part of the instructor to arrange as well as the effort of students to attend. Instructors presumably invite speakers or create events that are complementary to the other learning goals or strategies of the course. But the theory suggests that for students, time spent on the extra credit is a substitute for time spent on regular course activities. In fact, the theory suggests that even knowledge-motivated students will more than substitute time-on-extra-credit for time-on-regular study.

Table 5. Survey Question

What percentage of your students do you think have the following motivation? (n = 251)		
Student Primary Motivations	**Mean Percent of Students in Each Category**	**Percent of Respondents Ranking #1**
Earning a grade	50.6%	58.6%
Learning for future career goals or job skills	30.2%	29.5%
Knowledge and understanding for personal satisfaction	13.5%	5.2%
Other	5.7%	6.8%
Total	100%	100%

5 Who Attends Extra Credit Opportunities?

In the theory section we argued that when there is no interaction effect between extra credit and regular study time and there are no significant secondary costs to the extra credit, like extra commuting time or trading child care with a neighbor, then all students benefit from extra credit. If either of these conditions are not met, then the instructor must be more sensitive to the scale of the extra credit for everyone to potentially benefit. But notice that for X values sufficiently small, all students will benefit. In this section we suppose that the instructor designs a project that does benefit all students. But the amount of benefit a specific student gets will certainly vary. To investigate these differences, we will use the "increment" in utility from the extra credit opportunity denoted $U_{XC} - U_R$. We will begin with the special cases. For grade-motivated students, substitute from equations (10) and (7) (setting $h = 0$) and using the log properties of the utility function to write the increment in utility as:

$$U_{XC} - U_R = (g + j)(\log(M(X) - Z) - \log(M(0) - Z))$$

noting that $PHG + 1 = \frac{g(M(X)-Z)}{2(g+j)}$. In a comparative statics sense, as the weight on the grade in the utility function g increases, knowledge, the probability of higher grade, and the increment in utility from extra credit also increase.

A similar argument can be made for knowledge-motivated students. Using equations (11) and (7) (setting $g = 0$), the increment in utility from the extra credit opportunity is:

$$U_{XC} - U_R = (h + j)(\log(M(X) - \log\big(M(0)\big).$$

In a comparative statics sense, as the weight on knowledge in the utility function h increases, knowledge, the probability of higher grade, and the increment in utility from extra credit also increase.

Since the same general results hold true for knowledge-motivated students and grade-motivated students, it seems likely they hold for students motivated by grades and knowledge. An increase in the weight in the utility function on either the probability of a higher grade or on knowledge will likely increase both knowledge and the extra credit increment in utility. However, because of the complexity of the general solution, we will rely on numerical evidence. Using the example from Table 1 (C = 170, R = 34.5795, N = 200, α =1.3256, β = 1.0187, $j = 1,\ \gamma = 0$), Table 6 shows the relationship between knowledge and utility as the preference for either the probability of a higher grade, measured by g, or the preference for knowledge, measured by h, changes, changing only one parameter at a time. Numerical evidence suggests that these qualitative results are representative for interior solutions.

Table 6. Knowledge and the Extra Credit Increment in Utility

g (h held constant at 1)	K_{XC}	U_{XC}	K_R	U_R	$U_{XC} - U_R$
1	170	9.69	150	9.17	0.52
2	188.33	10.19	165.55	9.46	0.73
3	198.38	10.8	173.98	9.86	0.94
h (g held constant at 1)	K_{XC}	U_{XC}	K_R	U_R	$U_{XC} - U_R$
1	170	9.69	150	9.17	0.52
2	183.1	14.86	160.42	14.21	0.65
3	192.01	20.1	167.7	19.32	0.78

In sum, theory suggests that the instructor can structure extra credit events or activities so that all students benefit. But it may be that students have something like adjustment costs in switching time from regular study to the extra credit opportunity. Students may have behavioral rules-of-thumb. It may be that the net increment from the extra credit opportunity must exceed some threshold before some students attend. In these cases, better students, whom we represent in the theory as those who place a higher weight on either grades or knowledge in a comparative statics sense, have a larger increment in utility from extra credit and would be more likely to attend an event.

The empirical survey asked instructors about their perceptions of who would attend extra credit events. Survey participants were told to suppose the existence of a hypothetical series of on-campus speakers, and asked about perceived student willingness to attend those events. We assume that participants based their responses to this hypothetical on their real-world experiences with offering extra credit through various channels. Using the question: "In your experience which students would be more likely to attend these extra credit opportunities?," we proxy the instructor's perceptions of student preference for grades or knowledge by whether a student was an A student, a B student, and so forth. See Table 7 for responses. We also construct a collapsed variable, with A students labeled as 1 and all other responses labeled as 0, which we will use for estimation.

A null hypothesis that the proportion of instructors saying A students are more likely to attend is 50 percent or smaller is rejected with a p value of 0.038. Indirect evidence of instructor estimates of the overall proportion of students that will attend extra credit events will be presented in the next section.

If we assume that A students have greater utility weights on grades and knowledge than other students, then one suggestion of our model is that they have a greater utility gain from the availability of extra credit, and thus are more likely to attend. So instructors who believe that A students are most likely to attend have a perception of students that aligns with our utility model and we can test what correlates with that perception. Table 8 reports Probit estimation of the probability of response that A students are most likely to attend, compared to all other responses, along with marginal means for each category (what the model predicts for probability if all data points were in that category).[1]

[1] We use this collapsed variable and a Probit estimation because we view A students as a different category, more motivated by grades and knowledge as opposed to leisure, compared to other students. Also, our categories are not fully ordered because

Table 7. Survey Question

Most Likely to Attend Extra Credit (*n* = 251)	
Type of Student	**Percent**
A Students	55.77%
B Students	20.31%
C Students	8.36%
D and F Students	1.99%
All Students Will Equally Attend	13.54%
Total	100%
Collapsed Variable	
A Students	55.77%
All other Responses	44.22%
Standard Deviation	0.498

Table 8. Probit Estimation Results

A Students Attend Extra Credit Events vs. All Else		
Variable	**Coefficient**	**Marginal Mean**
Constant	-0.757	
	(-1.58)	
1-3 years	-	0.401
		(0.114)
4-7 years	0.932*	0.724
	(2.47)	(0.056)
8-12 years	0.124	0.445
	(0.34)	(0.060)
13-20 years	0.275	0.499
	(0.72)	(0.069)
21-30 years	0.402	0.545
	(1.04)	(0.074)
30+ years	0.822	0.690
	(1.83)	(0.094)
Face to Face	-	0.569
		(0.033)
Hybrid	-0.145	0.422
	(-1.37)	(0.099)
Online	0.0292	0.579
	(0.11)	(0.088)

of the inclusion of the "All Students Will Equally Attend" response, making techniques such as an Ordered Logit model infeasible.

Table 8 continued.

Variable	Coefficient	Marginal Mean
Ranked Professor	-	0.509
		(0.049)
Full-Time Instructor	0.146	0.561
(Non-Tenure Track)	(0.68)	(0.056)
Part-Time Instructor	0.301	0.615
	(1.44)	(0.053)
Grade	-	0.574
		(0.039
Career	-0.123	0.530
	(-0.62)	(0.057)
Knowledge	-0.590	0.365
	(-1.45)	(0.132)
Other	0.251	0.660
	(0.70)	(0.113)
Belief that Flexibility Helps	-	0.526
		(0.033)
Belief that Flexibility Hurts	0.426*	0.672
	(1.97)	(0.061)
Business/Agri. Business	-	0.497
		(0.098)
Engineering	0.418	0.646
	(0.76)	(0.163)
Humanities	0.437	0.653
	(1.36)	(0.056)
Natural or Formal Sciences	-0.129	0.450
	(-0.40)	(0.065)
Pre-Professional	0.257	0.590
	(0.66)	(0.099)
Social Sciences	0.207	0.572
	(0.64)	(0.062)
Technical Education	-0.729	0.249
	(-1.06)	(0.186)
Instructors who do not give same credit makeups	-	0.492
		(0.039)
Instructors who do give same credits makeups	0.497**	0.667
	(2.63)	(0.048)
Pseudo R^2	0.100	
n	251	

Note: Figures in parentheses are *z* statistics where *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

Instructors are characterized by experience, appointment status, and fields; course delivery method is also included. As for experience, there is a positive coefficient on 4–7 years of experience. That is, instructors with 4–7 years of experience are more likely to pick the A student response than the comparison group of 1–3 years of experience. None of the other years of experience, nor any of the delivery methods, appointment status, or field variables were significant. Two pedagogical variables were included in the regression. The pedagogical practice variable is whether the instructor gives a full credit makeup if a final exam is missed. This coefficient is significant and positive. Instructors offering exam makeups are more likely to think that A students are more likely to attend the event. A pedagogical perceptions variable was also included. Instructors were asked whether they believe that grading flexibility helps or hurts students. Notice that the coefficient on the flexibility hurts variable is significant and positive. Instructors reporting that flexibility hurts students are more likely to choose the A students response.

With our model, we were able to show that different students receive different utility increments from the availability of extra credit, and we posit that those students who receive the largest increment are most likely to take advantage of extra credit opportunities. With this regression, we show that different instructors have different perceptions about which type of students fit that category.

6 When in the Semester Will Students Attend?

We turn now to the question of the timing of an extra credit event during the semester. The theory parameterizes an extra credit event by the time it takes the students, or equivalently, by the points earned. But it is possible to imagine other differences between extra credit events, in this case whether an event is scheduled earlier or later in the semester. The analysis above showed that an increase in $Y = (\alpha - \beta)X$ increases knowledge (and thus the probability of a higher grade), leisure, and utility. The assumption was that students know both α and β, the parameters that measure how time translates into semester points. Recall β is for time spent on regular study and α for time spent on the extra credit. But suppose there is something like a learning curve for the student in gaining knowledge about their own specific α and β, or for what really matters, about the size of the gap between them. In particular, suppose a student learns over the course of the semester that their own β is not as high as they had first thought (i.e., that semester points require more study time than they earlier imagined). In that case, the same theory that showed that extra credit opportunities are utility enhancing would suggest that more of them would be done later in the semester. The survey explored this issue by asking the questions shown in Table 9.

Table 9. Survey Question

When During the Semester Will Students Attend	
Suppose there are various on-campus speakers that students can attend for extra credit points, each all before the midpoint of the term. What percentage of students do you think would attend?	37.5% *SD* = 23.6%
What percentage of students do you think would attend if these speakers were at the end of the term rather than at midpoint?	53.1% *SD* = 26.9%
Paired *t*-test of equal means	*p* = 0.0000

Table 9 reports the average estimate of the percentage of students likely to attend an event based on when it is held in the semester. These results are supportive of Mays and Bower (2005) in that they suggest that instructors think students are more likely to attend events later in the semester as compared to before the midterm. Instructors were not asked for an overall estimate regardless of scheduling during the semester, but it seems reasonable to suppose that, on average, the estimate would have been between

37.5 percent and 53.1 percent. At a minimum, it seems that instructors predicted a considerable proportion of students would not attend an event.

Table 10 uses OLS to investigate the determinants of the responses to the questions in Table 9.[2] A fractional logit regression shows the same significance patterns.

Table 10. OLS Estimation of Regressions Examining Professor Expectation of Extra Credit Use

Variable	Percent Attending Before Midterm Event	Percent Attending Later in Term Event
Constant	65.24***	79.07***
	(8.10)	(8.19)
4-7 years	-19.30**	-16.13*
	(-3.10)	(-2.16)
8-12 years	-17.93**	-20.60**
	(-2.92)	(-2.79)
13-20 years	-16.76**	-12.83
	(-2.63)	(-1.68)
21-30 years	-15.73*	-19.14*
	(-2.42)	(-2.45)
30+ years	-12.05	-21.69*
	(-1.61)	(-2.41)
Hybrid	13.47**	5.812
	(2.71)	(0.98)
Online	-3.200	-1.746
	(-0.68)	(-0.31)
Full-Time Instructor	-7.889*	-5.223
(Non-Tenure Track)	(-2.23)	(-1.23)
Part-Time Instructor	-6.169	-4.612
	(-1.76)	(-1.10)
Career	1.452	-6.091
	(0.44)	(-1.52)
Knowledge	17.71**	-7.829
	(2.69)	(-0.99)
Other	-5.407	-6.992
	(-0.92)	(-0.99)

[2] We believe an OLS model is appropriate here: while our results are technically left and right censored at 0 and 100, there are only a small number of observations at each end, so a tobit model is unnecessary. And while our percentage responses could be treated as fractions and analyzed with a fractional logit, we believe the linear probability model (equivalent to our OLS regression) is preferred to logit in this circumstance, due to the interpretation and interpretability of coefficients: we believe moving from 90 percent to 80 percent is equivalent to moving from 40 percent to 30 percent (as in a linear model), compared to 40 percent to 23 percent (as a log-odds logistic model would suggest). And this change would be easily represented by a coefficient of -10 in our regression.

Table 10 continued.

Variable	Percent Attending Before Midterm Event	Percent Attending Later in Term Event
Belief that Flexibility Helps	2.234	4.428
	(0.62)	(1.03)
Engineering	10.33	-5.268
	(1.13)	(-0.48)
Humanities	-15.45**	1.424
	(-2.89)	(0.22)
Natural or Formal Sciences	-8.290	-1.343
	(-1.54)	(-0.28)
Pre-Professional	-11.80	-8.234
	(-1.81)	(-1.05)
Social Sciences	-14.32**	-12.06
	(-2.63)	(-1.85)
Technical Education	11.45	23.81
	(1.04)	(1.81)
Instructors Who Give Same Credit Makeups	0.765	2.774
	(0.24)	(0.73)
Adjusted R^2	0.125	0.03
n	251	251

Note: *t* statistics in parentheses; *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

Looking first at column 1, the percentage that will attend events before the midterm, notice that all levels of instructor experience (except for those with 30+ years of experience) gave a lower percentage than the comparison group of instructors with 1–3 years of experience. Turning to delivery method, instructors of a hybrid class have higher beliefs about attendance as compared to instructors of face-to-face courses. Full-time instructors (i.e., non-tenure track) have lower predictions compared to tenured or tenure-track faculty. Fields also matter in some cases, with instructors in the humanities and social sciences giving lower estimates than the comparison field of business. Pedagogical variables are not significant. There was one more interesting result; instructors who said that students were most motivated by knowledge (as compared to being motivated by grades or careers) gave a much higher estimate of the percentage of students that will attend an event before midterm. Column 2 provides the results for the question about events later in the semester. In this case, instructors of all levels of experience (except for those 13–20 years) again gave a lower percentage than the comparison group of instructors with 1–3 years of experience. The overall impression from Table 10 is that instructors with more experience will give lower estimates of student attendance, regardless of when the event is held during the semester.

Remember that in the model, students only complete extra credit if it increases their utility through its effects on knowledge, grades, and leisure, which have different effects based on students' motivations—specifically, values for g and h (our survey did not include questions about additional or more specific student motivations for behavior). One possible explanation of our results is that new instructors overestimate the effects of extra credit as perceived by their students (that is, they overestimate their students' values of g and h in the model—how motivated students are by grades and knowledge compared to leisure), and thus overestimate students' likelihood of completing that extra credit, compared to more experienced instructors with better-calibrated models. Other significant effects can also be interpreted as differences in student motivations between fields, course types, etc., and by differences in professor perceptions of those motivations.

7 Other Flexible Grading Options

The survey also asked about another hypothetical situation: students are only graded on their top six out of seven homework assignments, and may or may not submit the seventh assignment. Respondents were asked what percent of students would submit the seventh, out of those who had completed the first six assignments, and to rank categories of students by motivation on their likelihood of completing the assignment. While this scenario is technically not extra credit, it illustrates many similar concepts to extra credit. Overall, instructors expected an average of 48.8 percent of students to complete the assignment. The plurality of instructors thought that knowledge-motivated students were most likely to complete it, and grade-motivated students least likely to. This aligns with the idea that this assignment would contribute to knowledge creation, but only minimally improve course grades.

As a final comment, in the larger sense offering extra credit or dropping homework assignments are two ways of providing flexibility in grading for students, a more abstract issue touched on in the survey. Table 4 shows the percent of instructors who believe that grading flexibility overall helps or hurts students. Recall that in the Probit regression about which students will attend extra credit events, we saw that instructors who answered that grading flexibility hurts are more likely to choose the A student response. Instructors who answered that grading flexibility helps students were more likely to choose some other response to the questions, either another grade or all students will attend equally. It appears that those who think flexibility helps are more likely to think students besides A students will attend an extra credit event. On the other hand, instructors who offer same credit makeup exams, a different kind of grade flexibility, were more likely to choose the A student response rather than one of the others. Perhaps in at least some instructors' thinking offering extra credit with the options it provides for students is substantively different than offering a makeup for a required final exam. In any event, a strong majority of instructors believe grading flexibility helps students, even if they operationalize that flexibility somewhat differently. Instructor perceptions might be said to be nuanced.

8 Conclusion

Economics instructors may wonder if offering extra credit opportunities to students enhances student effort and takeaway knowledge. The theoretical results of the current paper suggest that it depends crucially on whether the extra credit makes regular study time more efficient or not. If it does not, then the model suggests that it is reasonable to suppose that students will ask their instructors for extra credit events as they increase knowledge and the probability of a higher grade but also leisure. Students, even knowledge-motivated ones, may reduce their regular study time by more than the time they devote to the extra credit.

When extra credit increases the productivity of regular study time, the results are a bit more complex. For small scale extra credit activities, the qualitative results are the same as above. But when the extra credit event requires a relatively large time commitment on the part of the student, it may be the case that the increase in productivity of study time prompts the student to do enough more of it that leisure is actually reduced. It is also possible to create an extra project so large no student would do it.

While many instructors care very much about student utility and perceptions, they may also have other goals. When there is feedback between the extra credit activity and regular study time—and more is not necessarily better—the instructor may try to scale the extra credit to maximize knowledge. Our results suggest that for projects of about that scale, leisure is decreasing as the size of the extra credit project increases. The implication is that student utility is maximized before knowledge is. Students would prefer a smaller project than the instructor, but they would still do the knowledge maximizing extra credit as it gives greater utility than not doing it. In some circumstances an instructor may be able to structure an extra credit project that actually increases the learning of regular study time. On the surface, the prospect seems quite appealing. These results suggest that considerable nuance is required.

Finally, the main empirical results from the instructor perceptions survey suggest that instructors think A students are more likely to attend, and that all students will be more likely to attend an event later in the semester. These results align with outcomes from our model. Findings also suggest that instructors with more experience give lower probabilities to student attendance at extra credit events. Last, the instructor perception survey found that instructors believe knowledge-motivated students are most likely to complete an additional assignment to replace a lower grade, while grade-motivated students least likely to, suggesting that extra class activities often contribute to knowledge enhancement while only marginally improving student grades.

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Teaching and Educational Methods

Teaching Forward Contracts in Undergraduate Courses in Agribusiness and Agricultural Economics Programs

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Abstract
This article presents teaching materials for teaching forward contracts in undergraduate courses in agribusiness and agricultural economics programs, as well as educational materials for Extension and outreach activities. The teaching materials include: (a) an introduction to spot and forward contracts as market exchange mechanisms and an explanation of the main differences between these two types of contracts; (b) a discussion of the business rationale for using forward contracts, as compared to spot contracts; (c) a simple economic framework explaining the mechanics of forward contracts; and (d) analytical problem sets demonstrating applications of this framework in the U.S. beef, pork, and milk supply chains. The teaching note includes analytical problem sets, multiple choices questions, and answer keys for all questions.

1 Introduction

The use of various types of agricultural marketing agreements that are alternatives to traditional spot market transactions, including forward contracts, have increased in many agricultural industries in recent decades (MacDonald and Korb 2011; MacDonald 2015; Adjemian et al. 2016). Using the food supply chain perspective, forward contracts are market exchange mechanisms, which facilitate efficient movement of products and payments throughout the food supply chain. Using the perspective of firms, forward contracts are essential for proper business planning and are also important risk management tools used to manage output and input price risks, as compared to spot market alternatives.

This article presents teaching materials that can be used to teach a topic on forward contracts in undergraduate courses in agribusiness and agricultural economics programs, as well as educational materials for Extension and outreach activities. To explain economic and business aspects of forward contracts, they are compared to spot contracts. The teaching materials include (a) an introduction to spot and forward contracts as market exchange mechanisms and an explanation of the main differences between these two types of contracts (Section 2); (b) a discussion of the business rationale for using forward contracts, as compared to spot contracts (Section 3); (c) a simple economic framework explaining the mechanics of forward contracts (Section 4); and (d) analytical problem sets demonstrating applications of this framework in the U.S. beef, pork, and milk supply chains. The teaching note includes the problem sets, multiple choice questions, and answer keys to all questions. Table 1 presents a list of student learning objectives.

Table 1. Student Learning Objectives

	Student Learning Objective (SLO)
SLO #1	Students should be able to explain a simple market exchange mechanism and the difference between spot contracts and forward contracts using the perspectives of sellers and buyers.
SLO #2	Students should be able to explain the difference between an input forward contract and an output forward contract.
SLO #3	Students should be able to discuss the business rationale for using forward contracts, as compared to spot contracts.
SLO #4	Students should be able to provide examples of spot contracts and forward contracts.
SLO #5	Students should be able to explain an economic framework describing the mechanics of forward contracts using the perspectives of sellers and buyers.
SLO #6	Students should be able to apply the economic framework in the representative agribusiness settings to evaluate economic effects of the input and output forward contracts on contract parties (seller and buyer).

2 Spot and Forward Contracts: Economics

Spot contracts and forward contracts are alternative agreements that sellers and buyers can use to sell and purchase products. In terms of economics, spot and forward contracts are market exchange mechanisms. From a seller's perspective, these contracts are output marketing contracts because products sold are outputs for sellers. From a buyer's perspective, these contracts are input procurement (purchasing) contracts because products purchased are inputs for buyers.

This section explains the economics of spot and forward contracts using the concept of market exchange. This section further defines the key differences between these two types of contracts.

2.1 Spot and Forward Contracts as Market Exchange Mechanisms

The key elements of any market exchange are a product, a seller, and a buyer of this product. Assume that a certain quantity of the product is available now or will be available in the future. The seller has the title (ownership) of the product. To enter a market exchange, the seller and the buyer reach an agreement on product quantity and price per unit. During the market exchange, the product quantity and title are exchanged for the product price (payment). As a result of the market exchange, the seller transfers the product and its title to the buyer, and the buyer accepts the product and its title from the seller and makes the payment to the seller.

Consider a simple market exchange (either a spot market contract or a forward contract), where Q is product quantity (measured in physical units) and P is product price (measured in \$ per unit). The total \$ value of this market exchange (contract) is $P * Q$.

From the seller's perspective, the product is output. P is output price,[1] Q is output quantity, and $P * Q$ is the total revenue associated with this market exchange (contract). The revenue has a positive effect on profit. The seller has a business and economic incentive to negotiate a higher price for the product they sell.

From the buyer's perspective, the product is input. P is input price,[2] Q is input quantity, and $P * Q$ is the total costs associated with this market exchange (contract). The costs have a negative effect on profit. The buyer has a business and economic incentive to negotiate a lower price for the product they buy.

[1] The output price is also referred to as selling price, price received, and price charged.
[2] The input price is also referred to as price paid and purchasing price.

2.2 Spot and Forward Contracts: Differences

A spot contract is an agreement between a seller and a buyer for an *immediate* delivery of a product in exchange for a payment. A forward contract is an agreement between a seller and a buyer to deliver a product in exchange for a payment at a specified *future* date.[3] In the case of both spot and forward contracts, the seller transfers the product title to the buyer.[4] From the seller's perspective, output forward contracts are also referred to as agricultural marketing contracts. According to the U.S. Department of Agriculture Economic Research Service, "Marketing contracts are agreements to exchange a specified asset for a certain price on a future date" (Prager et al. 2020, p. 3).[5]

The first difference between spot contracts and forward contracts is whether the products are available at the moment these contracts are signed (entered). Spot contracts are used when the product is already produced, and a desired quantity of this product is available to sell and to purchase immediately (on the spot). As in the case of spot contracts, forward contracts are also used when the product is produced and available to sell and to purchase. In contrast to spot contracts, forward contracts are also used when the product is not produced yet, but it will be produced by the time these contracts are to be executed, that is, when the seller delivers the product to the buyer and the buyer makes the payment.

The second difference between spot contracts and forward contracts is a time period between the moment these contracts are signed (Step 1) and the moment these contracts are executed (Step 2). Figure 1 depicts a timeline of the market exchange process, which helps explain this difference.

- Step 1 is TODAY: the seller and the buyer reach an agreement on product quantity to be sold and product price to be paid; they sign the contract.

- Step 2 is FUTURE (LATER): the seller and the buyer execute their agreement; the seller delivers the product to the buyer, and the buyer accepts the product and makes the payment. The seller transfers the product ownership to the buyer.

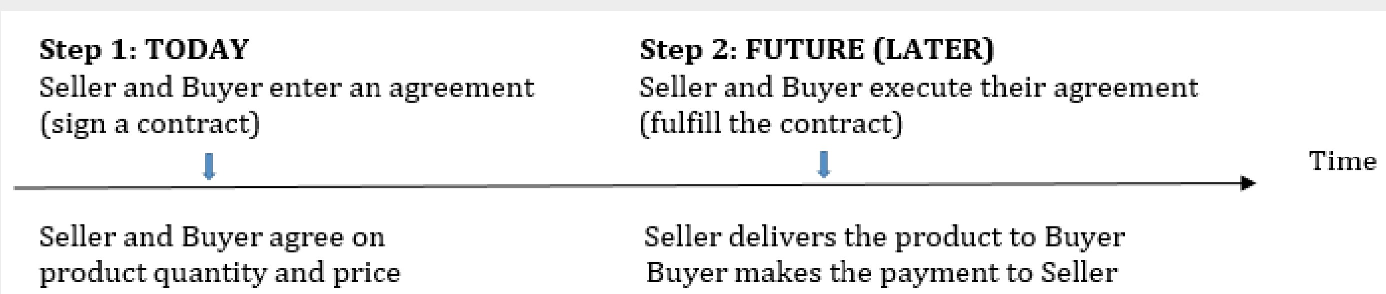

Figure 1. Timeline of a Market Exchange Process

[3] Appendix 1 briefly explains legal aspects related to spot and forward contracts in light of the Uniform Commercial Code.
[4] Paul, Heifner, and Helmuth (1976); Heifner, Wright, and Plato (1993); MacDonald et al. (2004); and MacDonald (2015) provide detailed discussions of the use of spot and forward contracts in agriculture, as well as agricultural industry examples, which can be used to supplement the lecture materials. The terminology related to forward contracts may vary depending on agricultural industry (MacDonald et al. 2004; MacDonald and Korb 2011; Adjemian et al. 2016; Greene 2019; Prager et al. 2020).
[5] Agricultural *marketing* contracts should be distinguished from agricultural *production* contracts; both types of contracts are common in agriculture (Roy 1963; MacDonald et al. 2004; Prager et al. 2020). Under production contracts, agricultural producers perform services for a contractor (i.e., a food processor) in exchange for a fee. The examples of services include growing crops and raising animals. Agricultural producers do now own the product they produce for the contractor. The contractor maintains the product ownership, provides selected agricultural inputs, and markets the product.

If Step 1 and Step 2 take place on the same day or within a few days, then the contract is referred to as a spot market contract. If there is a certain time period between Step 1 and Step 2 (a few weeks to months), then the contract is referred to as a forward contract.

Figure 2 depicts a timeline of spot and forward contracting in light of crop production and marketing sessions, which further clarifies the differences between spot and forward contracts. Spot contracts can be entered only immediately after the harvest (after agricultural products have been produced) and during the marketing season. In contrast, forward contracts can be entered during the pre-production, production, and marketing seasons. However, forward contracts can be executed only immediately after the harvest and during the marketing season, when agricultural products are produced and available to be delivered.

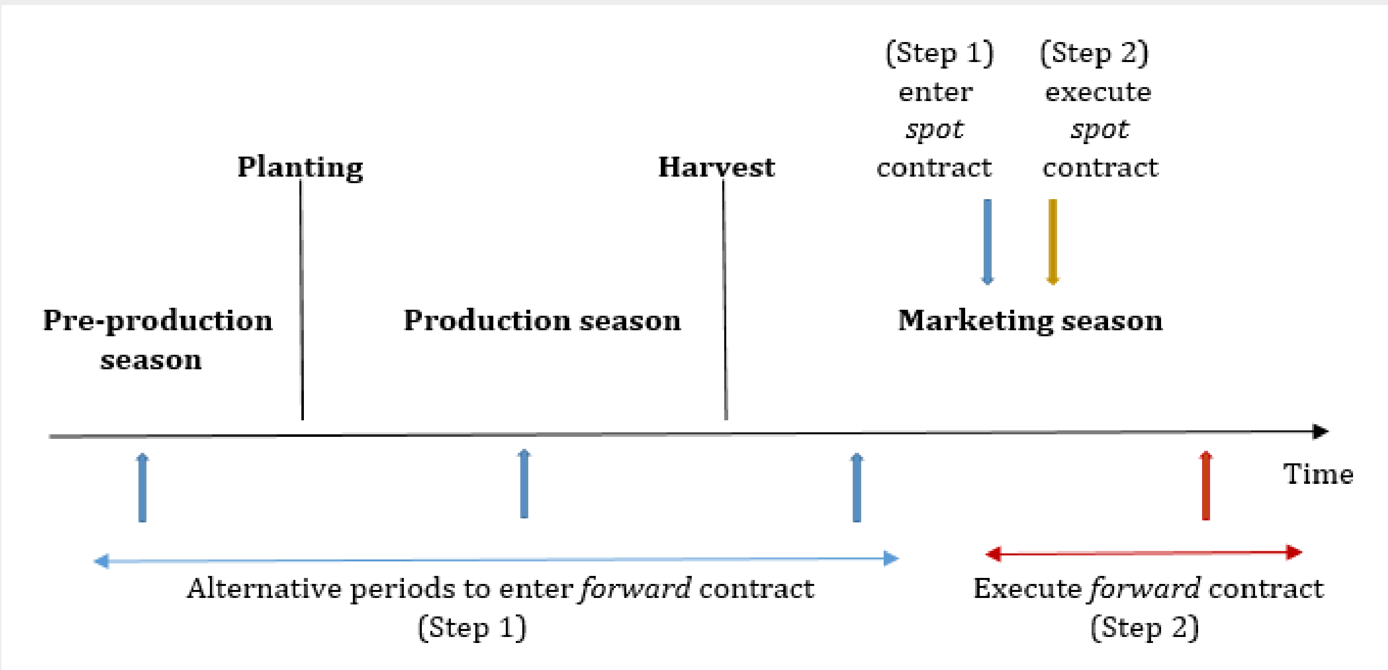

Figure 2. Timeline of Spot and Forward Contracting in Light of Crop Production and Marketing Seasons

3 Forward Contracts: Business Rationale and Risks

Why do firms use forward contracts instead of spot contracts? A general answer is proper business planning of input procurement (purchasing) and output marketing. The input quantity, quality, and timely availability from preferred geographic locations affects the output quantity, quality, and timely availability for different output distribution channels.

Input forward contracts are important for effective production planning. Input forward contracts allow to secure in advance input quantities and prices. Input purchasing (procurement) is a cost side of business. Output forward contracts are important for effective output marketing and pricing (sales). Output forward contracts allow to secure in advance output market outlets and prices. Output marketing is a revenue side of business.

Many types of food supply chain participants use forward contracts:

- Agricultural producers *purchase* some agricultural inputs from agricultural input suppliers using *input* forward contracts;
- Agricultural producers *sell* agricultural products to food processors using *output* forward contracts;
- Food processors *purchase* large quantities of agricultural products from agricultural producers using *input* forward contracts;
- Food processors *sell* large quantities of food products to food retailers using *output* forward contracts; and
- Food retailers *purchase* large quantities of food products from food processors using *input* forward contracts.

Different types of food supply chain participants use spot contracts:

- Fruit and vegetable producers (farmers) sell their products at local farmers markets to consumers shopping at these markets;
- Livestock producers sell their livestock at livestock auctions;
- Grain producers sell their grains to local grain elevators;
- Fresh fruit and vegetable producers (farmers and their cooperatives) sell their products to wholesalers and retailers at the shipping points located in large agricultural production regions;[6]
- Wholesalers sell domestic and imported fresh vegetables and fruits to other wholesalers and food retailers at large terminal markets;[7] and
- Food retailers sell food products to consumers.

Forward contracts are also important risk management tools. Table 2 summarizes risk categories that agricultural producers face. Forward contracts may help firms manage risks (uncertainty) related to input and output quantities and prices.[8] Using forward contracts, sellers and buyers lock in product prices and quantities today, while the product delivery and payment take place in the future.

In certain situations, there may be disadvantages to using forward contracts, as compared to spot contracts. First, there are risks related to changes in spot market prices between the moment a forward contract is signed and the moment it is executed. For a seller, the forward contract price accepted today may be lower than the spot market price in the future, meaning that the seller eventually sells the product at a lower price by using a forward contract. Had the seller not used a forward contract and used a spot market contract instead, the output price would have been higher for them. The seller loses money by using the forward contract in this situation. Similarly, for a buyer, the forward contract

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[6] The examples are open (spot) market sales by first handlers of specialty crops at the shipping points reported in the U.S. Department of Agriculture Specialty Crops Market News report available at https://www.ams.usda.gov/mnreports/wa_fv102.txt. This report presents prices associated with open (spot) market sales by first handlers of the products. Prices vary depending on the products' growing origin, variety, size, package, and grade.

[7] The examples are open (spot) market sales of specialty crops at the terminal markets reported in the U.S. Department of Agriculture Specialty Crops Market News report available at https://www.ams.usda.gov/mnreports/aj_fv020.txt. This report presents prices associated with open (spot) market sales. Prices vary depending on the products' growing origin, variety, size, package, and grade.

[8] Forward contracts should be distinguished from futures contracts. Both types of contracts are risk management tools and are often referred to as forward pricing methods (Paul, Heifner, and Helmuth 1976; Wolf and Olynk Widmar 2014). Futures contracts are standardized contracts with the pre-determined terms and conditions. Futures contracts are traded on the organized Exchanges. Chicago Mercantile Exchange is one of the largest Exchanges in the world (CME Group 2022).

Table 2. Categories of Risks in Agriculture

Risk Category
Price Risks
Output price risks arise from the uncertainty related to changes in prices received for agricultural outputs.
Input price risks arise from the uncertainty related to changes in prices paid for agricultural inputs.
Production Risks
Output quantity (yield) risks arise from the uncertainty related to the production processes of crops and livestock, that are due to weather, diseases, pests, and other factors affecting the quantity and quality of agricultural outputs.
Market Risks
The risks arising from the uncertainty related to locating a buyer or a seller.
Institutional Risks
The risks arising from the uncertainty related to government policies and programs affecting agricultural production and/or farms or farm households' finances.
Financial (Repayment) Risks
The risks arising from changes in interest rates, credit availability, or other market conditions.
Human (Personal) Risks
The risks arising from health or personal relationship issues that can affect the farm business (accidents, illness, death, and divorce).

Source: Adopted from Prager et al. (2020).

price accepted today may be higher than the spot market price in the future, meaning that the buyer eventually purchases the product at a higher price by using a forward contract. Had the buyer not used the forward contract and used a spot market contract, the input price would have been lower for them. The buyer loses money by using the forward contract in this situation.

Second, there are risks for agricultural producers as sellers, if they are not able to produce the needed output quantity required to fulfill a forward contract. For example, this can happen due to bad weather or a disease outbreak. In this case, agricultural producers must buy the output quantity elsewhere to fulfill the forward contract, which might lead to a loss for these producers. Third, there are risks involving nonperformance by a buyer, who fails to provide a payment on time or at all, possibly due to bankruptcy or insolvency.

4 Framework Explaining the Mechanics of Forward Contracts

Figure A2 included in Appendix 2 presents an economic framework explaining the mechanics of forward contracts.[9] The framework focuses on economic effects (gain or loss) of the same forward contract on the contract parties: the buyer and the seller of the product. This forward contract is an output forward contract for the seller, affecting the output price they receive and consequently their revenue and profit. The same forward contract is an input forward contract for the buyer affecting the input price they pay and consequently their costs and profit. The main components of the framework are explained in the following.

[9] This framework is conceptually similar to the mechanics of futures contracts, when the seller and the buyer gain or lose between TODAY and the FUTURE depending on the patterns of the spot and futures price movements between the moment a futures contract is purchased (or sold) TODAY and the moment this contract is sold (or purchased) in the FUTURE.

Consider a product that theoretically can be sold and purchased using a forward contract or a spot contract.[10] The product is sold and purchased using a forward contract. Assume there is a seller and a buyer for this product. Now consider two points in time: TODAY and the FUTURE (LATER). Assume there is a time period of a few weeks or months between TODAY and the FUTURE. The following actions take place TODAY and in the FUTURE:

- TODAY: the seller and the buyer sign a forward contract by making (entering) an agreement on product quantity (Q) to be delivered in the FUTURE and forward price (FP) to be paid for this product in the FUTURE.

- FUTURE (LATER): the seller delivers the product to the buyer (Q), and the buyer accepts this product (Q) and makes a payment to the seller (FP in $/unit or the total payment of $FP * Q$).

The spot market is an alternative to the forward contract. While the spot market is not used by the seller and the buyer in this situation, the spot market price for the FUTURE (SPL) is used as a reference price within the framework to evaluate economic effects of the forward contract on the seller and the buyer.

The spot market price may change between TODAY and the FUTURE. This price may increase or decrease. TODAY the seller and the buyer do not typically know whether the spot market price will increase or decrease between TODAY and the FUTURE. TODAY, when the seller decides on the forward price to accept, the seller would typically accept the forward price which covers production costs.

Using a proper business planning perspective, both contract parties will gain from using the forward contract. Using a risk management perspective, one contract party will gain, and another contract party will lose from using the same forward contract, as compared to the spot market alternative. In the latter case, the key thing is whether the forward price accepted today will be higher or lower than the spot market price in the future. The price difference (FP-SPL) affects who loses and who gains from using the same forward contract. The two scenarios are explained in Figure A2 in the FUTURE (LATER) section (Appendix 2).

The first scenario is that the forward price accepted today is higher than the spot price in the future (Figure A2: FUTURE (LATER) section Scenario 1). In this scenario, the seller gains because by using the forward contract the seller increases the output price, relative to the spot price, which consequently increases revenue and profit. In contrast, the buyer loses because by using this forward contract, the buyer increases the input price, relative to the spot price, which consequently increases costs and decreases profit.

The second scenario is that the forward price accepted today is lower than the spot price in the future (Figure A2: FUTURE (LATER) section Scenario 2). In this scenario, the seller loses because by using the forward contract, the seller decreases the output price, relative to the spot price, which consequently decreases revenue and profit. In contrast, the buyer gains because by using this forward contract, the buyer decreases the input price, relative to the spot price, which consequently decreases costs and increases profit.

5 Forward Contracts in the U.S. Beef, Pork, and Milk Supply Chains

The analytical problem sets included in the teaching note demonstrate applications of the economic framework in the U.S. beef, pork, and milk supply chains. The main decision maker is an agricultural producer: cattle farmer, hog farmer, or dairy farmer. This agricultural producer uses an input forward contract to purchase feed from an animal feed supplier and an output forward contract to sell output

[10] Spot contracts are associated with spot markets, which examples include a local livestock auction, a shipping point, and a terminal market.

(cattle, hogs, or milk) to a food processor. The decision maker uses a fixed price forward contract. They know the level of the forward price when they sign the forward contract.

In a real-world industry setting, many forward contracts used in the food supply chain have deferred pricing systems. A deferred pricing means that the product price is to be determined later using a price formula or another price determination method. Forward contracts with deferred pricing specify a base price and a price differential reflecting differences in the value of the seller's product from the one associated with the base price (Paul, Heifner, and Helmuth 1976). In addition to the product price and quantity-related provisions, forward contracts include provisions related to product quality, delivery conditions, dispute resolution, and others. The agricultural product quality in forward contracts is typically specified by referring to the U.S. Department of Agriculture Agricultural Marketing Service Grades and Standards (2022).

Using the terminology common to the livestock industries, the category of forward contracts with differed pricing used in these industries includes forward and formula contracts (Adjemian et al. 2016; Greene 2019). Both forward and formula contracts establish a price determination method for the price to be determined later, when fed cattle and hogs are delivered to the meat packing plants. Forward contracts use the Chicago Mercantile Exchange cattle and hog futures contract prices as a base (or a reference price) to determine the actual price to be paid to fed cattle and hog producers later. Formula contracts use a spot market price as a base (or a reference price) to determine the actual price to be paid to fed cattle and hog producers later. The spot (cash) market prices used in the formula contracts are typically spot (cash) prices reported by the U.S. Department of Agriculture Agricultural Marketing Service (Adjemian et al. 2016; Greene 2019).

Beef and pork packers (meat processors) benefit from using forward and formula contracts ("input procurement practices" for packers) because they can secure the constant flow of the required quantity of fed cattle and hogs with the essential quality characteristics to their meat processing (packing) plants. Fed cattle and hog producers (farmers) also benefit from using forward and formula contracts, because they can secure in advance a market outlet for their fed cattle and hogs and reduce market and price risks (Table 2).

Similarly, dairy farmers benefit from using forward contracts. The milk marketing arrangements that many dairy farmers have with dairy cooperatives (who market milk on behalf of farmer-members) and milk processors are designed as forward contracts (Ling and Liebrand 1996; Shields 2011; Wolf 2012; Wolf and Olynk Widmar 2014). The design of milk pricing systems used in forward contracts may be as simple as a fixed forward price or more complex when forward prices are tied to the Chicago Mercantile Exchange futures prices for manufactured dairy products (forward contracts with deferred pricing).

The forward prices for feed in input forward contracts used by dairy farmers also have deferred pricing systems. The feed forward prices in these contracts are typically tied to the Chicago Mercantile Exchange futures prices for grains, such as corn and soybean meal (Shields 2011; Wolf 2012; Wolf and Olynk Widmar 2014).

6 Conclusion

Given the increasing use of forward contracts in the food supply chain, teaching economic and business aspects related to forward contracts, mechanics of forward contracts, and industry applications in undergraduate courses in agribusiness and agricultural economics programs gains more importance. The teaching materials presented in this article and teaching note were used to teach forward contracts in a junior level "Economics of Agricultural Marketing" course and a junior level "Agribusiness Management" course at a land-grant university. As for teaching approaches, it is suggested to allocate two class sessions to this lecture topic. The first class session is to be allocated to economic and business aspects related to spot and forward contracts. The second class session is to be allocated to the economic framework explaining the mechanics of forward contracts and an in-depth explanation of one of the industry applications (the instructor solves one of the problem sets on the blackboard).

The teaching note includes analytical problem sets demonstrating industry applications, which can be used for in-class explanation, assigned as homework, and included in exams. The teaching note also includes multiple-choice questions and answer keys to all questions. The teaching materials are also suitable for educational Extension and outreach activities.

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Appendix 1. Spot and Forward Contracts: Legal Aspects

The Uniform Commercial Code (UCC)[11] establishes rules regulating contracts for sale of goods. Spot and forward contracts are contracts for sale of goods in light of UCC because agricultural commodities and food products are "goods." Goods are things that are movable, including unborn animals and growing crops.[12]

The UCC defines "contract for sale of goods" as the one that "includes both a **present sale** of goods and a **contract to sell goods at a future time.**" "A sale consists in the **passing of title** from the seller to the buyer **for a price**."[13] "A '**present sale**' means **a sale which is accomplished by the making of the contract**."

In light of UCC, spot contracts may be interpreted as present sales, and forward contracts may be interpreted as future sales. Spot contracts and forward contracts are legally binding agreements between sellers and buyers of the products. To be enforceable in court, these contracts must be in writing, if for $500 or more.[14]

[11] https://www.law.cornell.edu/ucc
[12] https://www.law.cornell.edu/ucc/2/2-105
[13] https://www.law.cornell.edu/ucc/2/2-106#Contract%20for%20sale_2-106
[14] https://www.law.cornell.edu/ucc/2/2-201

Appendix 2. Framework Explaining the Mechanics of Forward Contracts

SPOT MARKET	FORWARD CONTRACT (FC)	
	Seller Sells the product (output). Output price received affects revenue.	**Buyer** Buys the product (input). Input price paid affects costs.
TODAY **Spot Price = \$XX/unit** **"*SPT*"**	Seller and Buyer **sign a forward contract:** **Agree** on product **Quantity (*Q*)** to be delivered in the FUTURE and **Forward Price (*FP*)** to be paid in the FUTURE. *Q* is in physical units, and *FP* is in \$/unit. Forward contract \$ value = *FP* * *Q*.	
FUTURE (LATER) **Spot Price = \$YY/unit** **"*SPL*"**	**Seller delivers the product** to Buyer and **receives price** (*FP*).	**Buyer accepts the product** from Seller and **pays price** (*FP*).
	To evaluate economic effects (gain or loss) of the forward contract on Seller and Buyer: **compare Forward Price (*FP*) and Spot Price LATER (*SPL*), and calculate the price difference (PD).**	
	Scenario 1: *FP* > *SPL* and PD = *FP* – *SPL* > 0.	
	Seller *Gains* **Seller** has **increased the output price** by using FC. Seller's **revenue and profit increase.**	**Buyer *Loses*** **Buyer** has **increased the input price** by using FC. Buyer's **costs increase and profit decreases.**
	Scenario 2: *FP* < *SPL* and PD = *FP* – *SPL* < 0.	
	Seller *Loses* **Seller** has **decreased the output price** by using FC. Seller's **revenue and profit decrease.**	**Buyer *Gains*** Buyer has **decreased the input price** by using FC. Buyer's **costs decrease and profit increases.**

Figure A2: Framework Explaining the Mechanics of Forward Contracts

Note: Seller: Total Gain/Loss (\$) = Price Difference (\$/unit) * Quantity (Units).
Buyer: Total Gain/Loss (\$) = Price Difference (\$/unit) * Quantity (Units).
Forward Contract \$ Value = Forward Price (\$ per unit) * Quantity (Units).

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Teaching and Educational Methods

Coordinating Environmental and Trade Policy to Protect the Environment: A Pedagogical Approach

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JEL Codes: A20, F18, Q58
Keywords: Environment, international trade, teaching of economics

Abstract
Establishing appropriate environmental and trade policies is an important issue in today's globalized economy, and yet there is no comprehensive analysis in most environmental economics and international trade undergraduate textbooks of how such policies are interrelated. The purpose of this article is to provide a straightforward framework for teaching students how environmental and trade policies are indeed interconnected, utilizing the standard tools of intermediate microeconomics. Focusing on a single competitive market and (nonstrategic) welfare maximizing government, optimal environmental and trade policies are derived and explored. The framework is used to address several circumstances, including negative production and consumption externalities, small and large countries, and transboundary pollution.

1 Introduction

Significant damage to the environment, both locally and globally, pose a serious threat to the well-being of people around the world, and therefore most of the world's governments are today implementing policies that target local and global pollution. For example, countries confront the issue of rising greenhouse gas (GHG) emissions by implementing national policies, such as the Clean Air Act (CAA) in the United States, as well as pledging commitment to international agreements such as the Kyoto Protocol in 1997 and the Paris Agreement in 2015. When it comes to meeting emission reduction targets, cap-and-trade systems, which set a cap on overall emissions, and pollution taxes, which set a price per ton of (carbon) emissions, are preferred over command-and-control approaches due to their economic efficiency advantages. As of 2019, cap-and-trade systems have been preferred over pollution (carbon) taxes as exemplified by well-known cap-and-trade systems, including the European Union's (EU) Emission Trading System (ETS) and the Acid Rain Program of the U.S. Environmental Protection Agency (Lewis 2011). There are, however, three factors that recommend pollution taxes over cap-and-trade systems: (1) the price volatility of pollution permits, (2) the complexity and increased possibility of fraud with permit allowance trading, and (3) the possibility of under investment in pollution reduction technologies (Michalek 2016; Metcalf 2019).

Efforts in reducing GHG emissions might be suboptimal if policies are implemented without regard to the fact that international trade may adversely impact the environment (OECD 2019; World Trade Organization 2021). This concern is expressed by environmentalists who worry that trade might cause governments to set weaker environmental standards than warranted by the true cost of environmental damage (Esty 1994). Such "environmental dumping" may manifest either through "regulatory chill" or even a race to the bottom in environmental standards as countries compete for global market share and international investments (Esty 2001). In fact, disparate emission regulation, a situation with stringent emission regulation of industrialized nations and weaker emission regulations in the developing world, has been viewed as an impediment to meeting emission standards. Different regulations have indeed led to carbon leakage (Mehling et al. 2019; Böhringer, Schneider, and Asane-Otoo

2021), the relocation of production, and hence emissions from regulating countries to countries with weaker or no environmental regulation. That is, a strengthening of domestic environmental policy may cause a shift of production to countries with weaker standards, which in turn can raise global emissions. According to Böhringer et al. (2021), trade in carbon embodied in goods increased markedly until the 2007–2008 financial crisis due to increased offshoring of emission-intensive production from developed countries to developing countries.

Such concerns have promoted the idea of border adjustment (pollution tariff) policies, along with nations' existing pollution control policies. Recently, the EU proposed implementing a carbon border adjustment mechanism; that is, a carbon tariff on imports (Plumer 2021) by 2026, with a transitional phase from 2023 to 2025 (European Commission 2021). Aligning with the EU's decision, the United States is also evaluating the possibility of border taxes (Friedman 2021) as a form of transboundary pollution taxes. However, border taxes/border adjustments might provoke trade partners whose exporting firms may experience reduced sales and could create challenges to trade and violations of the General Agreements on Tariff and Trade (GATT). According to the World Trade Organization (WTO 1994), border adjustment levies may be permitted by provisions of Articles XX(b) and XX(g) that allow trade restrictions to "protect human, animal or plant life or health" and to ensure "the conservation of exhaustible natural resources." The most common border adjustments are taxes on imports and rebates on exports, both of which attempt to account for variation in pollution (carbon) "pricing" across nations. Although these policies may improve the environment, they are also favored by industries that are seeking a "level playing field" in environmental regulations that may reduce competitiveness. Although border adjustments could facilitate a level playing field, the GATT-approved exceptions only apply to environmental goals, they cannot be used to offset competitive disadvantages for domestic industries (Wiers 2008; Monjon and Quirion 2011). Hence, implementation of border adjustments should emphasize world (carbon) emissions, rather than carbon leakage. Other issues regarding border adjustments include how they relate to the domestic price on pollution, how they are best implemented, and whether border adjustments lead to production decline in GHG intensive sectors in pollution unregulated countries (Monjon and Quirion 2011; Balistreri, Kaffine, and Yonezawa 2019). According to Balistreri et al. (2019), correct environmental adjustments are complex. This is undoubtedly true, and the complexity of these issues cause different groups, including environmentalists, industrialists, and developing nations, to worry about environmental and trade policies adopted by nations. These are important concerns that are often shared by students in our courses. Given these misgivings, economics has an opportunity to explore how trade and environmental policies are interrelated, and whether these concerns are warranted.

Economics argues that any market distortion is most efficiently addressed at its source; that is, environmental market failures should be countered by environmental policy, not trade policy, and external distortions, market failures outside of the nation's borders, should be addressed by trade policy, not local environmental policies. In addition, to address more than one market distortion efficiently a policy maker needs at least as many policy instruments as the number of distortions and, again, the most efficient response is to address each particular distortion at its source (Bhagwati 1971). Thus, a nation facing both a negative production (consumption) externality and an external distortion, should adopt an appropriate environmental policy to deal with environmental problems and optimal trade policy to address external distortions. In this case, there is no real trade environment linkage *unless* there are either a greater number of market distortions than available policy instruments or constraints imposed on a nation; for example, a nation might deviate from an optimal environmental policy if it is constrained by either a multilateral (WTO) or regional international trade agreement (Krutilla 1991). In particular, faced with a domestic externality and trade distortions, as well as transboundary environmental externalities (a third market distortion), an absence of an international environmental institution suggests a need to coordinate trade and environmental policies.

As most current economic research is not easily accessible to undergraduate students, we present a framework that helps students understand how environmental and trade policies are interrelated in achieving environmental protection goals. We use a conventional partial equilibrium economic model, a model that assumes that governments have perfect information and seek to maximize national welfare, while considering one particular market in isolation. Partial equilibrium models are both useful and tractable in a trade and environment context as they clearly address the consequences of terms-of-trade effects, as well as allow us to easily discuss normative properties of policy actions (Krutilla 1991; Anderson 1992; Krutilla 2002). In international trade theory, the terms-of-trade is a relative price and defined as the price of exports divided by the price of imports. Thus, a positive (negative) terms-of-trade effect is when the price of exports increases (decreases) relative to price of imports; that is, a nation is able to import more (fewer) goods for the same volume of exports. The goal is to use this conventional and tractable model to explore what economic analysis recommends for optimal trade and environmental policies in disparate circumstances. Our focus is on what is optimal from the perspective of an individual country acting in its own self-interest, and the base case is a large open economy that faces a local negative production externality. That is, the country faces two market failures, the negative externality and monopoly power in trade (ability to manipulate the world price). This base case is then modified by assuming a small open economy, the existence of policy constraints, and transboundary pollution.

The next section introduces the basic assumptions underlying our approach. The model and its solution, as well as a few extensions are presented before the issue of transboundary pollution is introduced in section 4. The final section offers conclusions, as well as limitations.

2 Basic Assumptions

The economic model most familiar to students of economics is the standard supply and demand framework presented with linear supply and demand curves. The primary use of this competitive market model is to find market equilibrium and explore comparative statics, such as how government policy affects equilibrium price and quantity. Another frequent application is welfare analysis, the study of how government policies impact consumer surplus, producer surplus, as well as government revenue. Welfare analysis is also used in the presence of market failures, such as externalities or monopoly power. Although standard supply and demand is ordinarily and effectively presented graphically, there are applications that benefit from a more mathematical treatment, and one such application is the study of optimal environmental policy in open economies; that is, the derivation of optimal environmental policy in the presence of international trade and trade policies.

The important connection between environmental policy and international trade theory usually relies on general equilibrium analysis, but partial equilibrium analysis is more accessible to students of economics and also produces outcomes that are consistent with general equilibrium analysis. That is, rather than considering the aggregate economy with its many distinct markets, we focus on a particular market and conduct welfare analysis by exploring how unilateral government policies impact consumer surplus, producer surplus, government revenue, and the environment in the presence of market distortions. We thus build a familiar and tractable model of an open economy that can be used to address common concerns raised about trade and the environment.

In particular, we consider a competitive market for a tradable good (see Britten-Jones, Nettle, and Anderson 1987; Krutilla 1991, 2002; Anderson 1992). Specifically, we assume a large number of utility-maximizing households, each of which with preferences given by $U_i(q_i^C, Q_i)$, where q_i^c is quantity consumed of a particular good and Q_i is quantity consumed of all other goods by consumer i, $i = 1, \dots, N_c$. The representative consumer has a budget (Y_i) constraint given by $pq_i^C + PQ_i = Y_i$, which implies that the constrained utility maximization yields a demand function $q^c(p, P, Y)$. Letting P be the numeraire (or benchmark unit) and defining p^c as a relative price accordingly, as well as assuming constant income levels, the demand function becomes $q^c(p^c)$. Similarly, competitive firms, $j = 1, \dots, N_p$ choose output levels (q_j) which maximizes profit (π_j), where $\max_{q_j} \pi_j = R_j(q_j) - C_j(q_j)$; that is, profit equals total revenue given the market price $(R_j(q_j) = p_p \cdot q_j)$ minus total cost $(C_j(q_j))$. The profit maximizing output level determines the market supply curve, $q^p(p^p)$.

Given these demand and supply functions, we derive optimal environmental policy in the presence of international trade and trade policies, government revenue, as well as environmental externalities. We thus consider an economy in which one group's production (or consumption) of a good imposes an externality on others through its effect on the environment; that is, marginal private and social cost of production (or benefit from consumption) differ. The reason for this divergence in cost may stem from either social preference for a clean environment having strengthened or a threshold level of pollution having been reached which triggers greater concern for the environment. For simplicity we assume there are no administrative or distortionary costs of collecting taxes or disbursing subsidies and all income distributional effects can be neglected. We also assume that all agents have full information and appropriately value the environment. In addition, we assume that the externality results from the production (or consumption) activity itself, not from use of a particular process, so that a tax or subsidy on production (consumption) is equivalent to a tax/subsidy on the source of the externality and is therefore the optimal environmental policy for addressing the distortion. This modeling approach allows for a better focus on the connection between environmental regulation and trade policies, without qualitatively affecting model conclusions. As is true for comparative static analysis, changes in preferences, technology, and factor location are not considered. Below we initially assume that environmental costs are "local," without transboundary pollution effects, and in the subsequent section we introduce transboundary pollution into the model.

3 The Model: Policy Coordination with Local Pollution

We assume that national welfare reflects the net benefits from the production, consumption, and trade of a homogeneous good, q. Benefits are represented by consumer surplus $C(\cdot)$, producer surplus $P(\cdot)$, and tax and tariff revenues. Consumer surplus is a function of quantity consumed, which in turn depends on the price paid by consumer, $C(q^c(p^c))$, assuming $\frac{\partial C}{\partial q^c} > 0$ producer surplus is a function of quantity produced, which is determined by the price received by producers, $P(q^p(p^p))$ and assuming $\frac{\partial P}{\partial q^p} > 0$; environmental tax revenue (R_e) and tariff revenue (R_t, where t designates the tariff level) are given by $R_e = e \cdot q^p(p^p)$ and $R_t = t \cdot (q^c(p^c) - q^p(p^p))$, which implies that both pollution taxes and tariffs are formulated as per unit (specific) taxes applied to domestic production and trade flows, respectively. Costs include the environmental damage associated with production (consumption) activities.

The main presentation of the model centers on a large importing nation that faces a local negative production externality. Later we extend and briefly discuss how the results change in the cases of small nations, exporting nations, consumption externalities, as well as the implications of transboundary, or global, pollution. Expression (1) thus depicts national welfare for a negative production externality, W^p:

$$W^p = C(q^c(p^c)) + P(q^p(p^p)) + e \cdot q^p(p^p) + t \cdot (q^c(p^c) - q^p(p^p)) - E(q^p(p^p)), \quad (1)$$

where p^p and p^c denote price received by domestic producers and price paid by domestic consumers, respectively. Similarly, $q^p(p^p)$ represents domestic production, $q^{p'} > 0$; $q^c(p^c)$ represents domestic consumption, $q^{c'} < 0$; $E(q^p)$ is total environmental damage associated with production, $E' > 0$, $E'' \geq 0$. In addition, e is a specific environmental tax, while t represents a specific tariff on imports, $q^c(p^c) - q^p(p^p)$. The signs of the derivatives are sufficient to assure a maximum when expression (1) is optimized.

3.1 Open Nation with Negative Production Externality

The formulation in (1) contains several open economy equilibrium conditions, for the case of a production externality they include:

$$p^p = p^w + t - e \qquad \text{(supply-side price equilibrium), and} \qquad (2)$$

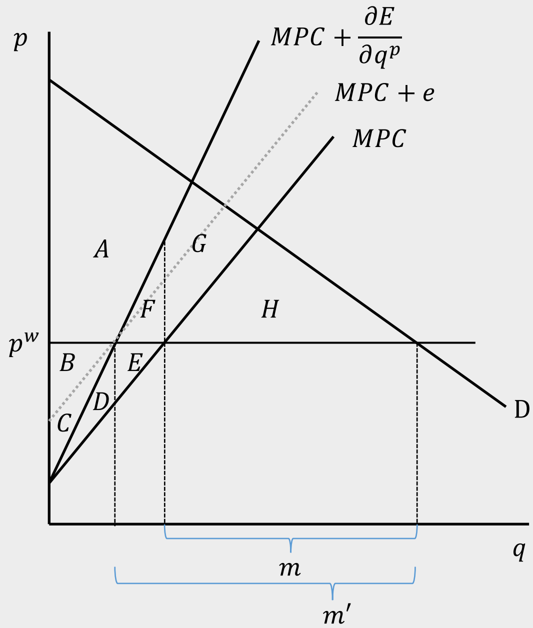
$$p^C = p^w + t \qquad \text{(demand-side price equilibrium),} \qquad (3)$$

where p^w denotes the world terms-of-trade. These expressions show that in an open economy, a trade policy (t) creates a wedge between the internal relative price and the terms-of-trade $(p^p = p^c \neq p^w)$, while a domestic production tax (e) creates a wedge between the price consumers pay and the price producers receive $(p^c = p^w \neq p^p)$. The latter wedge is possible because trade flows from abroad eliminate any potential shortage or surplus.

To close the model, we specify a trade equilibrium, a relationship that determines the global terms-of-trade, p^w, and represents equilibrium between export supply and import demand in the global market. For an importing nation, import demand $M(p^p, p^c)$ is, $M(p^p, p^c) = q^c(p^c) - q^p(p^p)$, while export supply (provided by the rest of the world) can be denoted as, $X(p^w) = q^{p*}(p^w) - q^{c*}(p^w)$, where $X' > 0$, and where q^{p*} and q^{c*} represent production and consumption in the rest of the world. Trade equilibrium is obtained where:

$$M(p^p, p^c) = q^c(p^c) - q^p(p^p) = X(p^w). \qquad (4)$$

This model can be described by diagrams that are familiar from both environmental economics and international trade theory. Although our ultimate interest lies in the complex issues that pertain to large nations, we proceed in steps by first considering a small economy facing a negative production externality (Figures 1 and 2). Figure 1 thus shows a small open economy that faces a negative production externality in the form of pollution, which it addresses by adopting a specific pollution tax (e). As can be seen in the diagram, as well as in the corresponding table, welfare analysis indicates that a Pigouvian tax will unambiguously raise national welfare (areas F and C); the loss in consumer and producer surplus is outweighed by government revenue and an improved environment.



	No Tax	Pigouvian Tax
Consumer Surplus	AFGH	AFGH
Producer Surplus	BCDE	BC
External Cost	DEF	D
Government Revenue	---	CD
National Welfare	AGHBC	AFGHBC+C
Change		+FC

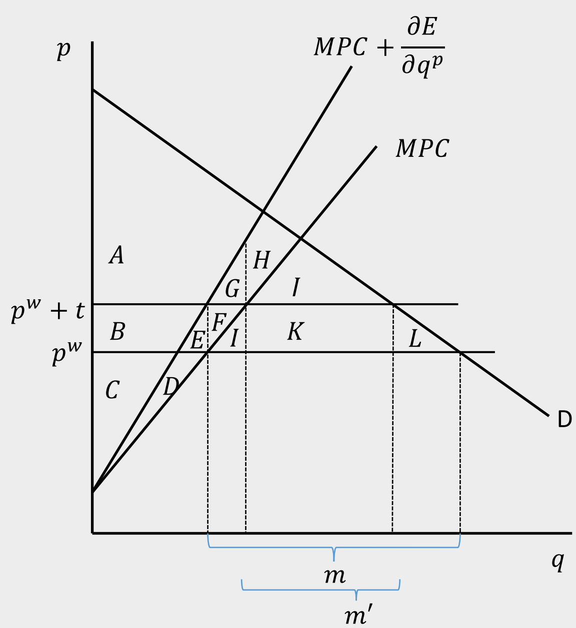
The Pigouvian tax improves national welfare by reducing environmental degradation.

p^w is the world price before import tariff, and the variables m and m' represent imports before and after a Pigouvian tax, respectively.

MPC is marginal private cost; $\frac{\partial E}{\partial q^p}$ is marginal external damage.

Figure 1. Diagram of a Small Open Importing Nation Facing a Negative Production Externality: Welfare Analysis Before and After a Pigouvian Tax (e)

Figure 2 again considers the case of a small nation with a negative production externality, but in this diagram the small nation adopts an import tariff. The accompanying analysis shows that adopting an import tariff will make this small nation unambiguously worse off by both creating a deadweight loss (IL) and raising environmental damage (FG). Combining the lessons from Figures 1 and 2, thus suggests that for a small nation facing a single market failure in the form of a negative production externality, free trade combined with a Pigouvian pollution tax is optimal; a conclusion verified in Case 1.

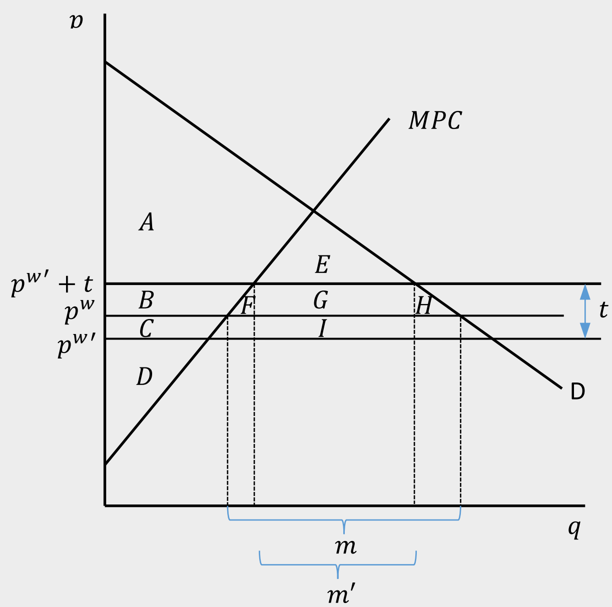


	No Import Tariff	Import Tariff
Consumer Surplus	ABEFGHIJKL	AGHJ
Producer Surplus	CD	BCDEF
External Cost	DE	DEFG
Government Revenue	---	K
National Welfare	ABCFGHIJKL	ABCGHJK
Change		-FG-IL

The import tariff reduces national welfare by both increasing environmental degradation and reducing consumer and producer surplus.

Figure 2. Diagram of a Small Open Importing Nation Facing a Negative Production Externality: Welfare Analysis Before and After an Import Tariff (t)

The analysis presented thus far ignores the possibility of a terms-of-trade effect, a second market failure due to a large nation being able to influence the terms-of-trade (the world price). In Figure 3, the standard diagram for a large open economy is offered. This diagram shows that an import tariff can in fact raise national welfare if the terms-of-trade effect (area I) outweighs the distortionary cost associated with the tariff (areas F and H). It can be shown (as discussed in footnote 3) that an optimal import tariff will in fact raise national welfare ($I > FH$).



	No Import Tariff	Import Tariff
Consumer Surplus	ABEFGH	AE
Producer Surplus	CD	BCD
Government Revenue	---	GI
National Welfare	ABCDEFGH	ABCDEGI
Change		-FH+I

The import tariff may increase welfare if the terms-of-trade effect (I) outweighs the deadweight loss (FH).

p^w = world price before import tariff
$p^{w'}$ = world price after import tariff (falls due to reduced global demand)
$p^{w'} + t$ = domestic price after import tariff

Figure 3. Diagram of a Large Open Importing Nation with Corresponding Welfare Analysis Before and After an Import Tariff (t)

Finally, Figure 4 shows that it is possible to draw a diagram that combines the two market failures depicted in Figures 1, 2, and 3; however, this diagram is not easily discussed through graphical welfare analysis. In addition, in the mathematical analysis below we add a third market distortion in the form of transboundary pollution. It is quite difficult to draw a diagram that encapsulates all these complex issues, and trying to conduct welfare analysis in order to determine what the optimal policies (e^*, t^*) are and how they are interconnected is very challenging. It is this particular challenge that we try to address by the mathematical analysis below.

Given the national welfare function and accompanying equilibrium conditions, a national government acting unilaterally with its available policy instruments, can choose either an environmental tax or a trade tax/tariff or both simultaneously, in order to maximize welfare. The goal for the government is thus to determine optimal environmental and trade policies in the presence of two market distortions, a negative production externality and monopoly power in trade (the ability of a large nation to influence the terms-of-trade).

To determine the optimal combination of environmental policy, e, and trade policy, t, we need to maximize W^p in (1) with respect to both e and t. That is, we need to find the best combination of (e, t) in order to maximize national welfare. This can be done in general (see Krutilla 1991), but in order to target our discussion to advanced undergraduate students of environmental economics and international trade,

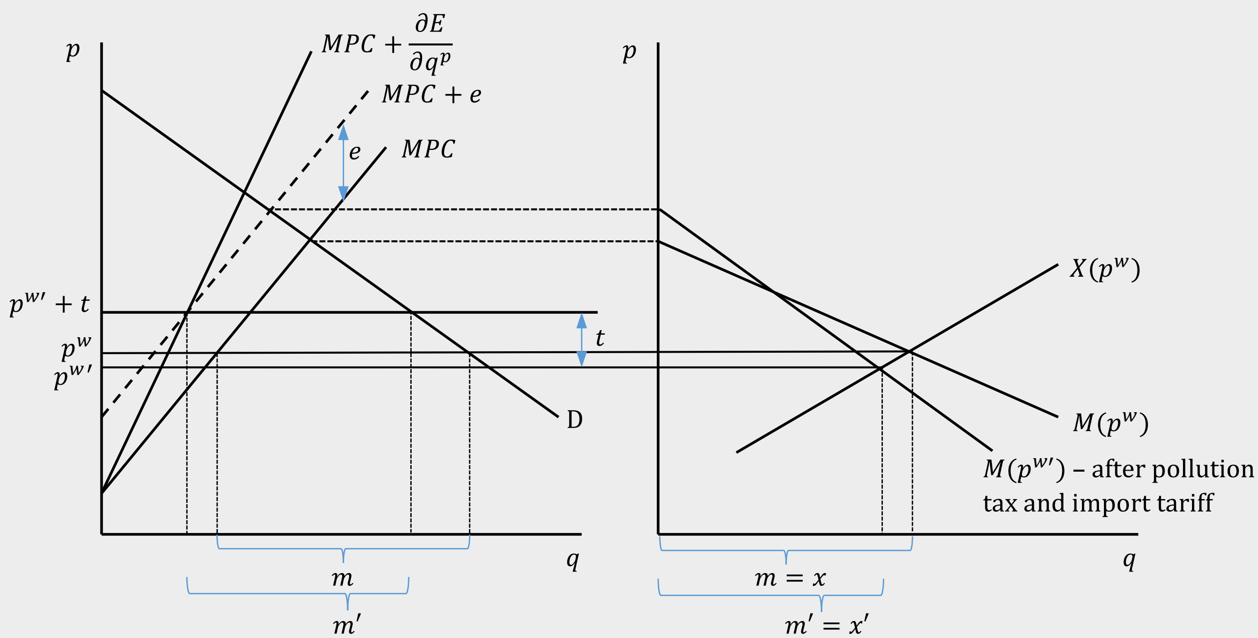


Figure 4. Diagram of a Large Open Importing Nation Facing Two Market Distortions, a Negative Production Externality and Monopoly Power in Trade

Note: MPC = marginal private cost = μq^p. Marginal environmental damage = $\partial E/\partial q^p$, which is assumed to be $2\gamma q^p$ so that optimal $e = 2\gamma q^p$. The variables m and x represent imports and exports (before tariff), respectively. The diagram on the left shows the domestic market, and the diagram on the right shows the world market.

we assume linear supply and demand functions. That is, we assume an inverse supply function $p^p = \kappa + \mu q^p$ and an inverse demand function $p^c = \alpha - \beta q^c$. Given linear supply and demand, producer surplus (P) and consumer surplus (C) can be expressed as:

$$P = \frac{\mu}{2}(q^p)^2 \text{ , and} \tag{5}$$

$$C = \frac{\beta}{2}(q^c)^2. \tag{6}$$

Using equation (1), which again depicts national welfare (W^p) in the presence of a negative production externality, the first-order conditions with respect to e and t are:

$$\frac{dW^p}{de} = \frac{\partial C}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{de} + \frac{\partial P}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{de} + \frac{\partial R_e}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{de} + \frac{dR_e}{de} + \frac{\partial R_t}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{de} + \frac{\partial R_t}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{de} - \frac{\partial E}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{de} = 0 \tag{7}$$

$$\frac{dW^p}{dt} = \frac{\partial C}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{dt} + \frac{\partial P}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{dt} + \frac{\partial R_e}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{dt} + \frac{\partial R_t}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{dt} + \frac{\partial R_t}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{dt} + \frac{dR_t}{dt} - \frac{\partial E}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{dt} = 0. \tag{8}$$

The equilibrium conditions (2) and (3) imply, $\frac{dp^p}{de} = \frac{dp^w}{de} - 1$, $\frac{dp^p}{dt} = \frac{dp^w}{dt} + 1$, $\frac{dp^c}{de} = \frac{dp^w}{de}$, $\frac{dp^c}{dt} = \frac{dp^w}{dt} + 1$. Furthermore, based on linear supply and demand we know that $\frac{\partial q^p}{\partial p^p} = \left(\frac{1}{\mu}\right)$, and $\frac{\partial q^c}{\partial p^c} = -\left(\frac{1}{\beta}\right)$. Finally, given the expressions for producer and consumer surplus as shown in equations (5) and (6), $\frac{\partial P}{\partial q^p} = \mu q^p$ and $\frac{\partial C}{\partial q^c} = \beta q^c$.

Incorporating these partial derivatives, as well as revenue and environmental damage functions, into equations (7) and (8), the first-order conditions become:[1]

$$\frac{dW^p}{de} = \beta q^c \left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{de}\right) + \mu q^p \left(\frac{1}{\mu}\right)\left(\frac{dp^w}{de} - 1\right) + e\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{de} - 1\right) + q^p + t\left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{de}\right)$$
$$-t\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{de} - 1\right) - \frac{\partial E}{\partial q^p}\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{de} - 1\right) = 0 \quad (9)$$

$$\frac{dW^p}{dt} = -\beta q^c \left(\frac{1}{\beta}\right)\left(\frac{dp^w}{dt} + 1\right) + \mu q^p \left(\frac{1}{\mu}\right)\left(\frac{dp^w}{dt} + 1\right) + e\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{dt} + 1\right) - t\left(\frac{1}{\beta}\right)\left(\frac{dp^w}{dt} + 1\right)$$
$$-t\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{dt} + 1\right) + (q^c - q^p) - \frac{\partial E}{\partial q^p}\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{dt} + 1\right) = 0\,. \quad (10)$$

Simplifying and solving 9 and 10 for optimal environmental and trade policies, e^* and t^* can be presented as:

$$e^* = \underbrace{\mu q^c \left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de} - 1}\right)}_{\text{Consumer Effect}} - \underbrace{\mu q^p \left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de} - 1}\right)}_{\text{Producer Effect}} + \underbrace{t\left(\frac{\mu}{\beta}\right)\left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de} - 1}\right) + t}_{\text{Tariff Revenue}} + \underbrace{\frac{\partial E}{\partial q^p}}_{\text{Environmental Effect}} \quad (11)$$

$$t^* = \underbrace{-q^c \left(\frac{\beta\mu}{\beta + \mu}\right)}_{\text{Consumer Effect}} + \underbrace{q^p \left(\frac{\beta\mu}{\beta + \mu}\right)}_{\text{Producer Effect}} + \underbrace{e\left(\frac{\beta}{\beta + \mu}\right) + (q^c - q^p)\left(\frac{\beta\mu}{\beta + \mu}\right)\left(\frac{1}{\frac{dp^w}{dt} + 1}\right)}_{\text{Government Revenue Effect}} - \underbrace{\frac{\partial E}{\partial q^p}\left(\frac{\beta}{\beta + \mu}\right)}_{\text{Environmental Effect}} \quad (12)$$

Expression (11) shows that the optimal environmental policy includes, and balances, the impact on consumers (first term), producers (second term), tariff revenue (third and fourth terms), and marginal environmental damage (fifth term). That is, a pollution tax changes all prices (p^c, p^p, p^w), which impacts both consumers, producers, the government, as well as the environment. In particular, consumers are worse off as price increases while quantity consumed decreases. This impact on consumers will argue for a lower pollution tax. Domestic producers are also made worse off due to a lower after-tax price and quantity, another effect that argues for a lower pollution tax. However, the positive impact on tariff revenue and the environment implies a more stringent pollution tax. Similarly, expression (12) shows that the optimal import tariff incorporates the impact on consumers, producers, production tax revenue (third and fourth terms), and marginal environmental damage. In this case,

[1] In the derivations we did not specify a functional form for the environmental damage function, $E^p(q^p)$, since many reasonable possibilities exist. Two common choices are: $E^p(q^p) = \gamma q^p$, so that $\partial E/\partial q^p = \gamma$ and constant (Krutilla 2002); $E^p(q^p) = \gamma \cdot (q^p)^2$, with $\partial E/\partial q^p = 2\gamma q^p$ and thus marginal environmental damage increases with production (Hultberg and Barbier 2004).

negative impacts on consumers and the environment (first and fifth terms) argue for a lower tariff, while greater government revenue (third and fourth terms) and producer surplus (second term) suggest higher tariff rates.

In order to evaluate these relationships, we must determine how the terms-of-trade is influenced by a pollution tax and an import tariff, respectively. Again, by our large country assumption, any domestic or trade policy will affect the terms-of-trade, and the national government should take these effects into account. A pollution tax reduces domestic production and thus *raises* import demand relative to foreign export supply, the resulting global shortage leads to an increase in terms-of-trade, but this increase is less than proportional to the change in the production tax. That is, a pollution tax will increase the terms-of-trade, but the increase will be smaller than the tax itself. The import tariff, on the other hand, *reduces* import demand relative to foreign export supply and the global surplus leads to a less than proportional decrease in the terms-of-trade. Again, an import tariff will reduce the terms-of-trade, but the change is smaller than the import tariff itself. In terms of the expressions in equations (11) and (12), we have:

$$0 < \frac{dp^w}{de} < 1 \text{ and therefore, } \left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de}-1}\right) < 0 \;;$$

$$-1 < \frac{dp^w}{dt} < 0 \text{ and therefore, } \left(\frac{\frac{dp^w}{dt}}{\frac{dp^w}{dt}+1}\right) < 0.$$

Given these terms-of-trade changes, we conclude from (11) and (12) that in the presence of an import tariff, optimal environmental regulation is lowered by its negative effect of higher prices on consumers, but the same effect benefits domestic producers. We also see that the presence of import tariffs suggests a need for a higher environmental tax, but this effect is somewhat alleviated by terms-of-trade effect. Of course, the main reason for the environmental tax is to address the level of marginal environmental damage, while the main reason for the import tariff is to manipulate the terms-of-trade. To determine the net effect of these various forces, we rearrange the optimal policy expressions, and simplify, to conclude that,

$$e^* = \mu\left((q^c - q^p) + \left(\frac{t^*}{\beta}\right)\right) \cdot \left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de}-1}\right) + t^* + \frac{\partial E}{\partial q^p} \tag{13}$$

$$t^* = -\left(\frac{\beta\mu}{\beta+\mu}\right)(q^c - q^p)\left(\frac{\frac{dp^w}{dt}}{\frac{dp^w}{dt}+1}\right) + \left(\frac{\beta}{\beta+\mu}\right)\left(e^* - \frac{\partial E}{\partial q^p}\right). \tag{14}$$

In order to deepen our understanding, while at the same time recognizing that trade and environmental policies are often determined separately (in fact, the WTO limits, with exceptions, member nations' ability to choose trade policies), we next consider several special cases.

Case 1: Small Country with Free Trade

Suppose first that foreign export supply is perfectly elastic, which means there is no terms-of-trade effect, and the country is classified as small. Consequently, $dp^w/de = 0$ and $dp^w/dt = 0$ and the terms-of-trade effects drop out and (13) and (14) reduce to:

$$e^* = t + \frac{\partial E}{\partial q^p}, \text{ and}$$

$$t^* = \left(\frac{\beta}{\beta+\mu}\right)\left(e - \frac{\partial E}{\partial q^p}\right).$$

Solving these two equations simultaneously show that a small country will optimally use the Pigouvian tax together with free trade. That is, optimal environmental regulation is equal to the marginal environmental damage, the standard Pigouvian tax, and optimal trade policy is no import tariffs, $t = 0$.[2]

Case 2: Large Country with Free Trade Constraint
If we assume zero tariffs, perhaps assuming that the nation is part of a free trade agreement, but reintroduce the terms-of-trade effects (assume a large nation), then (13) and (14) become,

$$e^* = \mu\big((q^c - q^p)\big) \cdot \left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de} - 1}\right) + \frac{\partial E}{\partial q^p}\text{, and}$$

$$t = 0.$$

Thus, in the absence of an import tariff, the optimal pollution tax for a large country will be *lower* than the standard Pigouvian tax (the first term is negative). The reason is that when constrained from using trade policy, the country must use its environmental policy as a second-best instrument to take advantage of the terms-of-trade effect. By, in effect, subsidizing domestic production, the nation reduces import demand relative to foreign export supply, which lowers the terms-of-trade. The lower world price is beneficial to the importing nation's consumers, and this positive effect justifies a lower pollution tax; that is, the nation accepts some additional environmental damage in return for lower prices.

Case 3: Large Country with Pigouvian Environmental Policy
If the nation does not account for the terms-of-trade effects when setting its environmental regulation and therefore adopts the Pigouvian tax, $e = \partial E/\partial q^p$, then equations (13) and (14) become,

$$e = \frac{\partial E}{\partial q^p}\text{, and}$$

$$t^* = -\left(\frac{\beta\mu}{\beta+\mu}\right)(q^c - q^p)\left(\frac{\frac{dp^w}{dt}}{\frac{dp^w}{dt}+1}\right).$$

The nation thus combines the Pigouvian tax with a positive optimal import tariff, which can be shown to equal the optimal tariff rate from international trade theory.[3] In fact, this combination of

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[2] Naturally, if we assumed a small country constrained by free trade ($t = 0$) from the very beginning, then equation (1) is $W^p = C\big(q^c(p^c)\big) + P\big(q^p(p^p)\big) + e \cdot q^p(p^p) - E^p\big(q^p(p^w)\big)$, and the first-order condition with respect to environmental regulation simplify to: $\frac{dW^p}{de} = 0 - \left(\frac{1}{\mu}\right)\mu q^p - e\left(\frac{1}{\mu}\right) + q^p + \left(\frac{1}{\mu}\right)\frac{\partial E}{\partial q^p} = 0$, with optimal pollution tax equal to marginal environmental damage, $e^* = \frac{\partial E}{\partial q^p}$, the standard Pigouvian tax.

[3] Totally differentiate equation (1) with respect to the environmental production tax and set equal to zero. Apply the equilibrium conditions from (2) and (3), and note that trade equilibrium (4), $q^c(p^c) - q^p(p^p) = X(p^w)$, implies that $\frac{\partial(q^p - q^c)}{\partial e} = \frac{\partial X}{\partial p^w}\frac{\partial p^w}{\partial e}$. Equation (11) then becomes: $\frac{dW^p}{de} = (q^p - q^c)\frac{\partial p^w}{\partial e} + \left(e - \frac{\partial E}{\partial q^p}\right)\frac{\partial q^p}{\partial p^p}\frac{\partial p^p}{\partial e} + t\frac{\partial X}{\partial p^w}\frac{\partial p^w}{\partial e} = 0$.
Assuming that $e = \frac{\partial E}{\partial q^p}$, gives us: $\left[(q^p - q^c) + t\frac{\partial X}{\partial p^w}\right]\frac{\partial p^w}{\partial e} = 0$, which implies, after some manipulation, that $t^* = -\frac{p^w}{\left(\frac{\partial X}{\partial p^w}\right)/\frac{p^w}{X}}$, where the term in the denominator denotes the elasticity of world excess supply and thus corresponds to the formula for optimal tariff rate for large importing nation.

environmental and trade policy is first-best; the domestic distortion is addressed by a domestic policy that targets the distortion at its source, and the external distortion (monopoly power in trade) is targeted by trade policy. There is an infinite number of (e, t) policy combinations that will satisfy equations (13) and (14), but they are associated with lower levels of national welfare compared to this (e^*, t^*) combination.

Case 4: Large Exporting Country

The same basic analysis can be conducted for a large exporting nation, with the only difference being the sign in front of the tariff revenue term in expression (1); that is, the tariff revenue term $t \cdot \left(q^c(p^c) - q^p(p^p)\right)$ becomes $t \cdot \left(q^p(p^p) - q^c(p^c)\right)$ instead. In fact, the optimal policies expressions shown in equations (13) and (14) remain, except that $(q^c - q^p) < 0$ in the case of an exporting nation. This affects some of the above conclusions. For example, if we assume free trade, then the optimal environmental tax is higher than the Pigouvian tax. That is, free trade encourages large exporting nations to over-protect the environment.[4] In this case the environmental tax must solve two distortions and the higher production tax acts as a second-best tool to achieve a positive terms-of-trade effect (mimicking an export tax). The high environmental tax reduces domestic production, reduces exports, and creates a global shortage that leads to an increase in the terms-of-trade, which is beneficial to the exporting nation (it gets more imports for the same amount of exports). Similarly, a small exporting nation should combine the Pigouvian tax with free trade. Finally, the first-best policy combination is for a large exporting nation to address the negative production externality with a Pigouvian tax and adopt an optimal export tax to maximize the terms-of-trade effect.

Cases 1–4 presented above show the complexity and interrelatedness of first-best environmental and trade policies for national governments. This complexity indicates the possibility that mistakes can be made in the choice of environmental policy; environmentalists may thus be warranted in their fear that international trade leads to inferior environmental policies and, on the other hand, industrialists may be justified in their concern that environmental policy will affect competitiveness. Of course, developing nations are justified in their worry about import tariffs since in the current model import tariffs are indeed a beggar-thy-neighbor policy; that is, the import tariff acts to reduce national welfare in the exporting nation.

In situations where a negative consumption externality could lead to environmental degradation, trade and environmental policies should be coordinated as well. Therefore, in the next section, we extend the model by introducing a negative consumption externality.

3.2 Open Nation with Negative Consumption Externality

If the nation instead faces a negative consumption externality, then the main change is that the external damage term in (1) is a function of domestic consumption, rather than domestic production. Another change is that environmental policy will now target consumers, so the government imposes a consumption tax. This change in equilibrium conditions (2) and (3) result in a corresponding change in partial derivatives; in particular, $dp^p/de = dp^w/de$, and $dp^c/de = (dp^w/de) + 1$. The resulting change in optimal policies stems from the different terms-of-trade implications; for a large importing nation, a consumption tax will reduce import demand relative to foreign export supply, and the ensuing global surplus will reduce the terms-of-trade, which is positive for the importing nation. Hence, we would expect that if the nation is constrained in its choice of trade policy (free trade), it will adopt a consumption tax that is *higher* than the Pigouvian tax as a second-best tool to benefit from the positive terms-of-trade effect (see Appendix for a derivation of this result). A consumption tax implemented by a large exporting nation increases exports, and the global surplus worsens its terms-of-trade, which means

[4] This is always true unless we value the environment infinitely, in which case we would not be producing anything in the first place.

that an exporting nation has an incentive to adopt a consumption tax that is *lower* than the Pigouvian tax. Finally, a small nation with a negative consumption externality should combine free trade policy with a Pigouvian tax, while a large exporting country's first-best policies is a Pigouvian tax combined with an optimal export subsidy (an unlikely import subsidy is optimal for the large importing nation).

4 The Model: Policy Coordination with Transboundary Pollution

As the introduction indicates, much of the environmental debate concerns the transboundary, or even global, nature of pollution. That is, much of pollution generated (such as carbon) crosses national borders, and therefore optimal policies must consider more than the domestically generated environmental damage. Of course, if part of the domestic pollution falls on other countries (e.g., acid rain), then the purely local approach would suggest *less* stringent environmental regulation (Esty 1994). This argument follows directly from our analysis above if we specify total environmental damage as $E(\varepsilon \cdot q^p)$, where $\varepsilon < 1$.

The more challenging case is global pollution, where production (consumption) abroad leads to environmental damage at home. In this case, unilateral domestic environmental regulation will never be first-best optimal, instead for true optimality an incentives-based cooperative agreement is needed. Although such global agreements are being implemented (Kyoto Protocol and Paris Agreement), they are currently not sufficient. Unilateral action is thus still needed, but unilateral domestic policy cannot regulate foreign production (except through possible small terms-of-trade effects). In fact, in the absence of first-best supra-national environmental policies, trade policy is an attractive second-best tool to address external market failures. The suggested combined use of domestic environmental policy and trade policy is, of course, exactly what our previous analyses have explored.

We thus revisit our analysis for a large importing nation facing a negative production externality that occurs both at home and abroad. Once again, we assume that national welfare reflects net benefits from consumption, production, and trade of a homogeneous good, q. Benefits are again represented by consumer surplus, producer surplus, and tax and tariff revenues, but costs now include the environmental costs associated with production activities both at home and abroad. In particular, assume that environmental damage can be described by $E\big(q^p(p^p), q^{p*}(p^w)\big)$, where $q^{p*}(p^w)$ represents all foreign production at the terms-of-trade p^w. The national welfare function thus becomes:

$$W^p = C\big(q^c(p^c)\big) + P\big(q^p(p^p)\big) + e \cdot q^p(p^p) + t \cdot \big(q^c(p^c) - q^p(p^p)\big) - E\big(q^p(p^p), q^{p*}(p^w)\big), \quad (15)$$

where p^p, p^c, and p^w still denote the price received by domestic producers, price paid by domestic consumers, and the world terms-of-trade, respectively, and all quantities are as described previously. However, $E(q^p, q^{p*})$ is now total environmental damage associated with production both at home and abroad, $E' > 0$, $E'' \geq 0$ for both variables. As before, e is a specific environmental tax, while t represents a specific tariff on imports. All equilibrium conditions remain the same as described by (2), (3), and (4), and we continue to assume linear supply and demand functions. Given the equilibrium conditions, a national government acting unilaterally choose environmental policy, trade policy, or both, in order to maximize (15). The first-order conditions are analogous to expressions (7) and (8), except for the added terms $\frac{\partial E}{\partial q^{p*}} \frac{\partial q^{p*}}{\partial p^w} \frac{dp^w}{de}$ and $\frac{\partial E}{\partial q^{p*}} \frac{\partial q^{p*}}{\partial p^w} \frac{dp^w}{dt}$, respectively. Solving these first-order conditions for optimal environmental and trade policies yields the rules for setting optimal policies for a large importing nation faced with transboundary pollution,

$$e^* = \mu\left((q^c - q^p) + \left(\frac{t}{\beta}\right) + \frac{\partial E}{\partial q^{p*}} \frac{\partial q^{p*}}{\partial p^w}\right) \cdot \left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de} - 1}\right) + t + \frac{\partial E}{\partial q^p} \quad (16)$$

$$t^* = -\left(\frac{\beta\mu}{\beta+\mu}\right)\left((q^c - q^p) + \frac{\partial E}{\partial q^{p*}}\frac{\partial q^{p*}}{\partial p^w}\right)\left(\frac{\frac{dp^w}{dt}}{\frac{dp^w}{dt}+1}\right) + \left(\frac{\beta}{\beta+\mu}\right)\left(e - \frac{\partial E}{\partial q^p}\right) \quad (17)$$

Although similar to equations (13) and (14), these expressions contain an additional term ($\frac{\partial E}{\partial q^{p*}}\frac{\partial q^{p*}}{\partial p^w}$) that denotes how environmental damage at home is affected by foreign production changes; that is, foreign producers adjust their output levels as the terms-of-trade changes, which in turn affect the level of transboundary pollution. In order to evaluate these expressions, we recall that $\frac{\partial E}{\partial q^{p*}}\frac{\partial q^{p*}}{\partial p^w} > 0$ and note that, $\left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de}-1}\right) < 0$ and $\left(\frac{\frac{dp^w}{dt}}{\frac{dp^w}{dt}+1}\right) < 0$. To better understand the implications of transboundary pollution, we start by assuming that the nation is constrained by a free trade agreement so that $t = 0$, which implies,

$$e^* = \mu\left((q^c - q^p) + \frac{\partial E}{\partial q^{p*}}\frac{\partial q^{p*}}{\partial p^w}\right)\cdot\left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de}-1}\right) + \frac{\partial E}{\partial q^p}\text{, and}$$

$$t^* = 0.$$

As before, the optimal pollution tax for a large importing nation is lower than the Pigouvian tax, but now for two distinct reasons. First, and as before, the environmental tax should be lower since a high production tax increases import demand relative to export supply (a global shortage) and therefore increases the terms-of-trade, a negative terms-of-trade effect for an importing nation. That is, e should be *lower* to limit this increase in the price of imports. Second, the environmental tax should be lower because a production tax shifts production from domestic producers to foreign producers, and the resulting increase in foreign production generates foreign pollution. Given transboundary pollution, the domestic government must take this indirect effect on global pollution into account. Thus, e should be *lower* to alleviate the secondary damage caused by increased pollution from abroad. Of course, in this case environmental policy acts as a second-best tool in the absence of trade policy. It is interesting to note that transboundary pollution, in the absence of an optimal import tax, gives the home country an added incentive to lower its environmental regulation. That is, free trade agreements may lead to a "regulatory chill" effect as feared by environmentalists. This is a result that is often missing from standard trade theory.

On the other hand, if a nation adopts the Pigouvian tax as usually suggested by environmental economics ($e = \partial E/\partial q^p$), then a nation should adjust its trade policy according to,

$$t^* = -\left(\frac{\beta\mu}{\beta+\mu}\right)\left((q^c - q^p) + \frac{\partial E}{\partial q^{p*}}\frac{\partial q^{p*}}{\partial p^w}\right)\left(\frac{\frac{dp^w}{dt}}{\frac{dp^w}{dt}+1}\right).$$

We see that the resulting optimal import tariff is positive for two reasons. In addition to the positive terms-of-trade effect, there is now a second benefit from an import tariff, namely that the import tariff will reduce foreign production and hence global pollution. That is, the import tariff lowers import demand relative to export supply, which means a falling terms-of-trade and falling foreign production. Of course, as foreign production declines so does foreign pollution, and this drop in transboundary pollution is beneficial to the importing nation. We see that there is an incentive and an actual benefit in terms of environmental damage, for a large importing nation to adopt an import ("carbon") tariff in order to influence foreign production. The ability to use import tariffs in this way, thus allows a country to adopt the Pigouvian tax targeting the negative production externality, while using trade policy to address all external distortions—both monopoly power in trade and a global negative production externality.

Table 1 summarizes first-best and second-best policies, in production and consumption externalities, for a large importing nation.

Table 1. Summary of Selected Optimal Environmental Taxes and Trade Tariffs for an Importing Nation

Negative Production Externality (Local)	
Large Nation:	Comments:
$e^* = \frac{\partial E}{\partial q^p}$ $t^* = -\left(\frac{\beta\mu}{\beta+\mu}\right)(q^c - q^p)\left(\frac{\frac{dp^W}{dt}}{\frac{dp^W}{dt}+1}\right)$	**First-best:** Combine a Pigouvian tax with optimal trade policy. This is optimal for both large and small nations.
$e^* = \mu\big((q^c - q^p)\big)\cdot\left(\frac{\frac{dp^W}{de}}{\frac{dp^W}{de}-1}\right) + \frac{\partial E}{\partial q^p}$ $t = 0$	**Second-best:** If constrained from using trade policy, use environmental policy to also target the external distortion. Adopt *lower* environmental regulation.
Negative Consumption Externality (Local)	
Large Nation:	Comments:
$e^* = \frac{\partial E^c}{\partial q^c}$ $t^* = -\left(\frac{\beta\mu}{\beta+\mu}\right)(q^c - q^p)\left(\frac{\frac{dp^W}{dt}}{\frac{dp^W}{dt}+1}\right)$	**First-best:** Combine a Pigouvian tax with optimal trade policy.
$e^* = -\beta\big((q^c - q^p)\big)\cdot\left(\frac{\frac{dp^W}{de}}{\frac{dp^W}{de}+1}\right) + \frac{\partial E}{\partial q^c}$ $t = 0$	**Second-best:** If constrained from using trade policy, use environmental policy to also target the external distortion. Adopt *higher* environmental regulation.

Table 1 continued.

Negative Production Externality (Transboundary)	
Large Nation:	Comments:
$e^* = \frac{\partial E}{\partial q^p}$ $t^* = -\left(\frac{\beta\mu}{\beta+\mu}\right)\left((q^c - q^p) + \frac{\partial E}{\partial q^{p*}}\frac{\partial q^{p*}}{\partial p^w}\right)\cdot\left(\frac{\frac{dp^w}{dt}}{\frac{dp^w}{dt}+1}\right)$	**First-best:** Combine a Pigouvian tax with the optimal trade policy, but trade policy must now address two external market failures: terms-of-trade effect and transboundary pollution. Since a small nation does not have the ability to address external distortions, it should combine the Pigouvian tax with free trade.
$e^* = \mu\left((q^c - q^p) + \frac{\partial E}{\partial q^{p*}}\frac{\partial q^{p*}}{\partial p^w}\right)\cdot\left(\frac{\frac{dp^w}{de}}{\frac{dp^w}{de}-1}\right) + \frac{\partial E}{\partial q^p}$ $t = 0$	**Second-best:** If constrained from using trade policy, use environmental policy to target both of the external distortions. Adopt *lower* environmental regulation to address both external distortions.

5 Conclusions

In order to combat an increasing threat to the environment, from production and consumption taking place both at home and abroad, countries must adopt policies that limit environmental damage. However, environmental regulation in the context of an open economy is a complex process due to the existence of multiple market failures and the limited reach of domestic policies. Policy decisions are thus more complicated than what standard analysis suggests in both environmental economics and international trade theory. In addition, whether a commodity is imported or exported, the size of the economy, existence of constraints, and whether pollution is local or transboundary/global critically impact the choice and level of appropriate policies.

The common advice of using environmental policy to address environmental externalities and trade policy to maximize the efficient allocation of resources, which usually implies free trade, still apply in certain circumstances. In particular, for a small nation unable to affect the terms-of-trade and facing purely local environmental damage, choosing the Pigouvian tax combined with free trade is optimal. Under these assumptions, the worries expressed by environmentalists, industrialists, and developing nations seem less relevant, and there is no need for supra-national institutions such as the WTO or its environmental equivalent. Of course, the world is more complex than the assumptions underlying the standard economic model, which is why the different groups fear the intentions and consequences of environmental and trade policies, especially when such policies are made in separation. Our model confirms arguments made by environmentalists (Esty 1994, 2001), that trade might cause governments to set weaker environmental standards, if pollution reduction policies were designed without taking into consideration the adverse effects of international trade on the environment. The fact that trade policy traditionally has been determined independently of both local and global effects of the resulting changes in production and consumption patterns further justifies these fears.

Lately the EU and the United States have proposed implementing carbon border adjustment mechanisms; that is, a tariff on imports tied to pollution created in the foreign production process. Such border adjustments, a form of trade policy, explicitly recognize that production taking place outside of a nation's environmental regulation jurisdiction might require nations to engage in unilateral trade policy as a second-best tool; that is, it is a recognition of the fact that global agreements, such as the Kyoto Protocol and the Paris Agreement, are currently not enough to slow environmental damage sufficiently.

Given the concerns and proposed policy responses, it is crucial to develop a tractable model that can provide a framework to discuss and think through these issues. Theoretical research published by professional economists is rarely accessible to undergraduate students or even Master's students; there is thus a need for a familiar model that allows the economics instructor to highlight the connection between environmental and trade policies. We propose the standard linear supply and demand framework. Using this model, we are able to rigorously discuss optimal policies for a self-interested nation that cares about national welfare, while recognizing the importance of the environment, in addition to consumption, production, and tax revenue. We show that environmental policies and trade policies are intertwined in complex ways, especially if the nation is constrained in its choices of such policies. We are further able to show that transboundary pollution does suggest a possible need for carbon border adjustments; an external negative externality can only be reached by a trade policy (barring the existence of first-best international agreements) that targets both terms-of-trade effect and transboundary pollution. At the same time, large nations' ability to manipulate the terms-of-trade in their favor suggest that a healthy degree of skepticism is warranted. Developing countries are correct in their suspicions that carbon taxes could be a form of beggar-thy-neighbor protectionism. It is thus true, as argued by Monjon and Quirion (2011) and Wiers (2008), implementation of border adjustments should emphasize world (carbon) emissions, rather than carbon leakage.

Of course, the current article suffers from many and important limitations. Using a partial equilibrium model and basic welfare analysis ignore important implications across the economy, in terms of demand for scarce resources, accompanying price effects, and secondary costs associated with raising taxes. The model is also static and does not allow for changes in preferences, technology, production processes, and factor movements. Another limitation is the absence of strategic interactions between both nations and producers. We recognize these limitations, but argue that presenting a tractable model that our students can understand with a relatively small investment in mathematical notations is a justified trade-off.

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Appendix: Large Importing Nation with Negative Consumption Externality

Suppose pollution originates from consumption, rather than from the production process. National welfare is then given by:

$$W^c = C\big(q^c(p^c)\big) + P\big(q^p(p^p)\big) + e \cdot \big(q^c(p^c)\big) + t \cdot \big(q^c(p^c) - q^p(p^p)\big) - E\big(q^c(p^c)\big),$$

where p^p and p^c denote price received by domestic producers and price paid by domestic consumers, respectively. $E(q^c)$ is total environmental damage associated with consumption, $E' > 0$, $E'' \geq 0$, e is a specific environmental tax, and t represents a specific tariff on imports, $q^c(p^c) - q^p(p^p)$. Denoting the global terms-of-trade as p^w, the open economy equilibrium conditions are:

$$p^p = p^w + t \qquad \text{(supply-side price equilibrium)}$$

$$p^C = p^w + t + e \qquad \text{(demand-side price equilibrium), and}$$

$$M(p^p, p^c) = q^c(p^c) - q^p(p^p) = X(p^w). \qquad \text{(trade equilibrium)}$$

We maximize W^c with respect to both e and t, while assuming linear supply and demand functions. The first-order conditions are:

$$\frac{dW^c}{de} = \frac{\partial C}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{de} + \frac{\partial P}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{de} + \frac{\partial R_e}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{de} + \frac{dR_e}{de} + \frac{\partial R_t}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{de} + \frac{\partial R_t}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{de} - \frac{\partial E}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{de} = 0,$$

$$\frac{dW^c}{dt} = \frac{\partial C}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{dt} + \frac{\partial P}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{dt} + \frac{\partial R_e}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{dt} + \frac{\partial R_t}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{dt} + \frac{\partial R_t}{\partial q^p}\frac{\partial q^p}{\partial p^p}\frac{dp^p}{dt} + \frac{dR_t}{dt} - \frac{\partial E}{\partial q^c}\frac{\partial q^c}{\partial p^c}\frac{dp^c}{dt} = 0.$$

Incorporating all partial derivatives and noting that $\frac{dp^p}{de} = \frac{dp^w}{de}$ and $\frac{dp^c}{de} = \frac{dp^w}{de} + 1$, the first-order conditions become:

$$\frac{dW^c}{de} = \beta q^c\left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{de} + 1\right) + \mu q^p\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{de}\right) + e\left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{de} + 1\right) + q^c + t\left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{de} + 1\right)$$
$$-t\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{de}\right) - \frac{\partial E}{\partial q^c}\left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{de} + 1\right) = 0$$

$$\frac{dW^c}{dt} = \beta q^c\left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{dt} + 1\right) + \mu q^p\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{dt} + 1\right) + e\left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{dt} + 1\right) + t\left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{dt} + 1\right)$$
$$-t\left(\frac{1}{\mu}\right)\left(\frac{dp^w}{dt} + 1\right) + (q^c - q^p) - \frac{\partial E}{\partial q^c}\left(-\frac{1}{\beta}\right)\left(\frac{dp^w}{dt} + 1\right) = 0.$$

Simplifying and solving for optimal environmental and trade policies, (e^*, t^*) give the following expressions:

$$e^* = -\beta q^c \left(\frac{\frac{dp^W}{de}}{\frac{dp^W}{de}+1}\right) + \beta q^p \left(\frac{\frac{dp^W}{de}}{\frac{dp^W}{de}+1}\right) - t\left(\frac{\beta}{\mu}\right)\left(\frac{\frac{dp^W}{de}}{\frac{dp^W}{de}+1}\right) - t + \frac{\partial E}{\partial q^c} \quad \text{(A1)}$$

$$t^* = -q^c\left(\frac{\beta\mu}{\beta+\mu}\right) + q^p\left(\frac{\beta\mu}{\beta+\mu}\right) - e\left(\frac{\mu}{\beta+\mu}\right) + (q^c - q^p)\left(\frac{\beta\mu}{\beta+\mu}\right)\left(\frac{1}{\frac{dp^W}{dt}+1}\right) + \frac{\partial E}{\partial q^c}\left(\frac{\mu}{\beta+\mu}\right) \quad \text{(A2)}$$

In order to evaluate these relationships, we determine how the terms-of-trade is influenced by a pollution tax on consumers and an import tariff. A pollution tax targeted at consumers reduces domestic consumption and thus *lowers* import demand relative to foreign export supply; the resulting global surplus leads to a decrease in terms-of-trade, but this decrease is less than proportional to the change in the consumption tax. The import tariff, on the other hand, *reduces* import demand relative to foreign export supply, and the global surplus leads to a less than proportional decrease in the terms-of-trade. That is,

$$-1 < \frac{dp^W}{de} < 0 \text{ and } \left(\frac{\frac{dp^W}{de}}{\frac{dp^W}{de}+1}\right) < 0 \text{ and } -1 < \frac{dp^W}{dt} < 0 \text{ and } \left(\frac{\frac{dp^W}{dt}}{\frac{dp^W}{dt}+1}\right) < 0.$$

Given these terms-of-trade changes for a large importing nation, facing a local negative consumption externality, we simplify and rearrange (A1) and (A2) to derive optimal environmental (e^*) and trade (t^*) policies:

$$e^* = -\beta\left((q^c - q^p) + \left(\frac{t^*}{\beta}\right)\right)\cdot\left(\frac{\frac{dp^W}{de}}{\frac{dp^W}{de}+1}\right) - t^* + \frac{\partial E}{\partial q^c}, \text{ and}$$

$$t^* = -\left(\frac{\beta\mu}{\beta+\mu}\right)(q^c - q^p)\left(\frac{\frac{dp^W}{dt}}{\frac{dp^W}{dt}+1}\right) - \left(\frac{\mu}{\beta+\mu}\right)\left(e^* - \frac{\partial E}{\partial q^c}\right).$$

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Case Study

Price-Fixing in the U.S. Broiler Chicken and Pork Industries

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JEL Codes: L1, L2, L4, L66, Q13
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Abstract
The motivations for this case study are recent developments in the U.S. broiler chicken and pork industries involving implementation of agricultural supply control practices by the largest broiler and pork processors in the United States. Buyers of broilers and pork filed antitrust lawsuits alleging that by implementing these supply control practices broiler and pork processors engaged in unlawful price-fixing conspiracies. The case study introduces economic, business, and legal issues related to implementation of supply control practices in the U.S. broiler chicken and pork industries. The case study presents economic models that help explain the conduct and performance of these industries in the analyzed setting, and it includes a basic market and price analysis. The intended audiences are undergraduate and graduate students, as well as extension and outreach communities. The teaching note includes multiple-choice questions and suggested answers to analytical, discussion, and multiple-choice questions. The teaching note also discusses teaching objectives, teaching strategies, and student background knowledge.

1 Introduction

The U.S. broiler chicken[1] and pork industries are concentrated industries, meaning a relatively small number of large broiler and pork processors produce and market most of the broiler chickens and pork products in the country. In 2020, the combined market share of the ten largest broiler processors was approximately 80 percent, and the combined market share of the two largest companies, Tyson Foods and Pilgrim's Pride (JBS USA), was almost 37 percent (Table 1). The same year, the combined market share of the ten largest pork processors was approximately 86 percent, and the combined market share of the two largest companies, Smithfield and JBS USA, was 43.6 percent (Table 1).

The U.S. broiler and pork industries are vertically integrated industries (MacDonald 2008; McBride and Key 2013; MacDonald 2014; National Chicken Council 2022). The broiler and pork processors control production processes at consecutive stages of the broiler and pork supply chains by using complex production contracts with broiler growers and hog farmers and/or by operating their own farms. For example, under production contracts, broiler and pork processors have control over the breeding stage, feed production stage, production (farm) stage, and processing stage of the broiler and pork supply chains. Broiler and pork processors own broilers and hogs at the production (farm) stage and maintain the product ownership throughout the supply chain. Consequently, broiler and pork processors make decisions affecting quantities of broilers and hogs produced at the production (farm) stage. Under production contracts, broiler growers and hog farmers provide services of growing broilers and raising hogs for broiler and pork processors in exchange for a fee.

Beginning in 2008, the largest broiler and pork processors implemented a series of agricultural supply control practices ("production cuts"), which affected quantities of broilers and pork produced and marketed in the country. The broiler and pork processors implemented production cuts to mitigate

[1] Broiler chickens are chickens raised for meat production. They will be referred to as "broilers" in this case study.

Table 1. The Ten Largest Companies in the U.S. Broiler Chicken and Pork Industries and Their Market Shares, 2020

	Broiler Chicken Industry			Pork Industry		
	Company	Production	Market share	Company	Plant slaughter capacity	Market share
		Million pounds per week	Percent		Heads per day	Percent
1	Tyson Foods	200.70	20.38	Smithfield	130,300	25.4
2	Pilgrim's Pride	161.66	16.4 (36.8)	JBS	93,000	18.2 (43.6)
3	Sanderson Farms	94.31	9.6 (46.4)	Tyson Foods	81,800	16.0 (59.5)
4	Mountaire Farms	62.13	6.3 (52.7)	Clemens Food	23,700	4.6 (64.2)
5	Perdue Foods	61.26	6.2 (58.9)	Seaboard Farms, OK	22,500	4.4 (68.6)
6	Koch Foods	60.74	6.2 (65.1)	Triumph Foods	21,300	4.2 (72.7)
7	Wayne Farms	48.80	5.0 (70.0)	Seaboard Farms, IA	20,400	4.0 (76.7)
8	Peco Foods	36.04	3.7 (73.7)	Hormel	19,000	3.7 (80.4)
9	George's	30.60	3.1 (76.8)	Indiana Packing Co.	16,700	3.3 (83.7)
10	House of Raeford Farms	28.90	2.9 (79.7)	WholeStone Farms	11,500	2.2 (85.9)
	Industry Total	984.74	100.0	Industry Total	512,370	100.0

Note: The broiler chicken production is the ready-to-cook weight of broiler chickens produced; the data are from WATT PoultryUSA (2021) and O'Keefe (2021). The pork plant slaughter capacity is from Meyer (2020). Market shares are calculated by the author. The cumulative market shares are in parentheses.

agricultural supply volatility and increases in feed prices, which contributed to an oversupply (overproduction) problem adversely affecting their profitability. There was a consistent increase in the quantities of broilers and pork produced, which the market could not absorb at prices profitable for broiler and pork processors.

Beginning in 2016, direct and indirect buyers of broilers and pork products started filing class action antitrust lawsuits against the largest broiler and pork processors.[2] The buyers alleged that by implementing production cuts and publicly communicating their intentions to implement these production cuts, the broiler and pork processors engaged in conspiracies (illegal agreements) with the purpose of fixing, increasing, and stabilizing prices of broilers and pork products paid by various participants in the broiler and pork supply chains (wholesalers, retailers, and final consumers), and consequently violated Section 1 of the Sherman Act (Popken 2017; Dewey 2018; Isidore 2018; Marotti 2018; Meyer 2018; National Hog Farmer 2018; Welshans 2018).[3] Beginning in 2017, some of the broiler and pork processors (defendants) started settling the lawsuits (Broiler Chicken Antitrust Litigation webpage 2022; Devenyns 2021; Pork Antitrust Litigation webpage 2022; Stempel 2021). As of the beginning of 2022, settlements with private parties in the broiler and pork industries totaled approximately $363 million and $122 million, respectively.

[2] Direct buyers (purchasers) are the ones who purchased broiler chickens and pork products directly from defendants. The examples of direct buyers are food retailers, wholesalers, restaurants, and institutional buyers. Indirect buyers (purchasers) are the ones who purchased these products indirectly from defendants, in particular from companies which sold these products but were not the defendants. The examples of indirect buyers are final consumers purchasing products from food retailers.

[3] Students are encouraged to read these magazine articles prior to studying the case study.

This case study introduces economic, business, and legal issues related to implementation of agricultural supply control practices in the U.S. broiler and pork supply chains. The case study presents economic models, which may explain conduct and performance of these industries in the analyzed situation, and a basic empirical market and price analysis utilizing publicly available data from the U.S. Department of Agriculture (USDA). The case study also highlights relevant antitrust issues.

This case study is suitable for a variety of undergraduate and graduate courses taught in agricultural economics and agribusiness programs, including microeconomics, agricultural economics, managerial economics, agricultural (or agribusiness) marketing, agricultural markets and prices (or agricultural prices), agribusiness management, supply chain management, and applied industrial organization. The case study is also suitable for extension and outreach communities. Table 2 summarizes student learning objectives.

Table 2. Student Learning Objectives (SLOs)

	Student Learning Objective
SLO #1	Students should be able to discuss structures of the U.S. broiler and pork industries.
SLO #2	Students should be able to explain production systems in the broiler and pork industries and discuss agricultural supply control practices (production cuts) implemented by the largest broiler and pork processors.
SLO #3	Using a graphical analysis, students should be able to explain two economic models, which may describe conduct and performance of the broiler and pork industries (changes in output quantity and output price; broilers and pork are "output") in the two situations. In the first situation, the industries are assumed to behave as classic oligopolies forming output price-fixing cartels. In the second situation, the industries are assumed to behave as perfectly competitive industries adjusting output quantity produced in response to increasing marginal cost (feed prices).
SLO #4	Students should be able to perform a basic empirical market and price analysis to evaluate changes in the market and price behavior in the broiler and pork industries between the period of agricultural supply control practices and a prior period.
SLO #5	Students should be able to conduct a price analysis and price forecast in the broiler and pork industries by using price flexibilities.
SLO #6	Students should be able to discuss legal (antitrust) issues involved and explain the role of the Sherman Act in regulating conduct of broiler and pork processors in the analyzed industry setting.

2 U.S. Broiler Chicken and Pork Industries: Structures

This section discusses structures of the broiler chicken and pork industries prior to the period of agricultural supply control practices and highlights changes in market concentration in the last 15 years.

The U.S. broiler and pork industries are concentrated industries. There is a relatively small number of large firms controlling most of the production and marketing in these industries. In 2007, prior to the implementation of agricultural supply control practices, the five-firm concentration ratio

(CR5)[4] in the broiler industry was 60.9 percent, and the ten-firm concentration ratio (CR10) was 75.8 percent (Weaver 2014). As of 2007, Pilgrim's Pride and Tyson Foods were the two largest firms in the broiler industry, with respective market shares of 31.3 percent and 25.9 percent; Perdue Farms was the third largest firm with a market share of 10.0 percent (Congressional Research Service 2009). In 2007, the five-firm concentration ratio (CR5) in the pork industry was 74.3 percent (Congressional Research Service 2009). As of 2007, Smithfield Foods and Tyson Foods were the two largest firms in the pork industry, with respective market shares of 28.4 percent and 17.6 percent; JBS USA was the third largest firm with a market share of 11.1 percent (Congressional Research Service 2009).

Several economically significant acquisitions took place in both industries in the period of 2007–2013 (Congressional Research Service 2009; Johnson 2009). JBS S.A. purchased Swift and Pilgrim's Pride in 2007 and 2009, respectively. After acquiring Pilgrim's Pride, JBS became the second largest broiler processor in the United States. JBS and Tyson Foods are companies operating in both the broiler and pork industries. Smithfield Foods was purchased by a Chinese-based company in 2013 (Daily Livestock Report 2013).

As indicated by changes in the four-firm concentration ratio (CR4), market concentration decreased in the broiler industry over the last 15 years. Given that since 2006 smaller companies grew faster than the largest companies in the broiler industry, its CR4 decreased from 57.8 percent in 2006 to 52 percent in 2020 (O'Keefe 2021). The combined market share of the two largest broiler processors, CR2, decreased from approximately 45 percent in 2006 to 35 percent in 2020 (O'Keefe 2021). As of 2020, the four largest companies in the broiler industry were Tyson Foods, Pilgrim's Pride (JBS USA), Sanderson Farms, and Mountaire Farms, followed by Perdue Foods and Koch Foods (Table 1).

Market concentration in the pork industry decreased in recent years. Because several new pork processing plants owned by hog producers were opened in Iowa, Minnesota, and Michigan in the last few years, CR4 in the pork industry decreased from approximately 70 percent in 2016 to 64 percent in 2020 (Meyer and Goodwin 2021). As of 2020, the four largest companies in the pork industry were Smithfield, JBS, Tyson Foods, and Clements Food Group, followed by Seaboard Farms and Triumph Foods (Table 1).

Broiler chickens and pork products are homogeneous products, which means that broiler chickens and pork produced by different processors are essentially the same products, with a small degree of product differentiation present. Buyers, who purchase these products directly from processors (retailers, wholesalers, restaurants, and institutional buyers), are relatively indifferent about which processor to buy these products from. Consumers purchasing these products at the retail level face some degree of product differentiation depending on whether they purchase raw meat (whole chickens, chicken parts, pork chops, pork ribs, etc.) or more processed products (chicken nuggets, sausages, bacon, etc.). Some of these products are completely cooked and can be consumed without any additional preparation at home, and some products require further preparation at home. At the retail level, broiler chickens and pork products are marketed under the brands of processors and food retailers.

Given product homogeneity, broiler and pork processors compete on price. The demand for broiler chickens and pork is inelastic. Broiler chickens and pork are products, which are imperfect substitutes to each other. Other products, which are imperfect substitutes to broiler chickens and pork, include other types of red meat (beef and lamb), other types of poultry (turkey), and fish. The broiler and pork industries have high barriers to entry. This means that a firm, which considers entering the industry, must incur substantial costs to build a processing plant or to purchase an existing plant.

[4] The *N*-firm concentration ratio is a commonly used measure of market concentration, which represents a combined market share of 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 of firms operating in concentrated industries. It is considered that if CR4 exceeds 75 percent, an industry is conducive to collusion, and if CR4 is smaller than 40 percent, an industry is not likely to present competition concerns (Hovenkamp 2005).

3 Agricultural Supply and Price Cycle, Production Systems, and Production Cuts

As in many agricultural industries, the broiler and pork industries are affected by a high level of agricultural supply and price volatility. This volatility is mostly due to the biological nature of agricultural production and other factors that agricultural producers (processors in this case study) cannot control (weather conditions affecting animal growth, a high volatility of feed and energy prices, animal diseases, etc.).

Agricultural producers tend to base their future production decisions on current output prices and profit, rather than on future prices (Kohls and Uhl 2002). Generally described, a natural agricultural production and price cycle is such that agricultural producers increase output quantity produced in response to high output prices, which will cause output prices to decrease in the future. Agricultural producers decrease output quantity produced in response to low output prices, which will cause output prices to increase in the future. This natural agricultural supply and price cycle leads to market situations (years) where there is overproduction (oversupply) of agricultural products, and output prices are below production costs, resulting in financial losses for producers and their industries (Kohls and Uhl 2002; Bolotova 2019).

This is especially true in the broiler chicken and hog/pork industries, where there is a time lag between the moment producers observe current output prices and the moment they adjust (increase or decrease) output quantity produced in response to these prices (Kohls and Uhl 2002; Norwood and Lusk 2008). In addition, there is a time lag between the moment production decisions are made and the moment the output is produced and marketed. Due to differences in biological cycles, agricultural supply and price cycles in the broiler chicken industry are much shorter than in the hog industry. As little as 8 weeks may take place between the moment a chicken is hatched and the moment it is sold to a wholesale or retail customer (Pruitt and Lavergne 2013). It takes approximately 25 to 28 weeks to raise a hog from the moment it is born to the moment it is sold to a processor (Pork Checkoff 2022a).

The following subsections briefly discuss production systems for broiler chickens and hogs/pork, decision makers whose decisions affect quantities of these products produced, and agricultural supply control practices implemented by the largest broiler chicken and pork processors.

3.1 Broiler Chickens

The production process for broiler chickens includes six vertically aligned stages (MacDonald 2008; MacDonald 2014; Weaver 2014; National Chicken Council 2022).[5]

1. Primary breeding stage: primary breeding companies produce breeder chicks with desirable genetics characteristics, which are delivered to breeder farms.
2. Breeder stage: on breeder farms, breeder chicks are raised to produce fertilized eggs, which are delivered to hatcheries.
3. Hatching stage: in hatcheries, fertilized eggs are placed in incubators (the incubation period is 3 weeks); young chicks are hatched, vaccinated, and delivered to grow-out farms.
4. Grow-out (farm) stage: on farms owned and operated by broiler growers, young chicks are raised to a desirable market age and weight (6 to 7 weeks).
5. Feed manufacturing stage: feed mills mix feed rations, which are used to feed breeder chicks and broiler chicks. The feed mixes include corn, soybean meal, and added vitamins and minerals.
6. Processing stage: in processing plants, chickens are slaughtered and processed in various chicken cuts and chicken products to be sold to wholesalers, retailers, restaurants, institutional buyers,

[5] A figure depicting these production stages can be downloaded on the webpage of the National Chicken Council, https://www.nationalchickencouncil.org/industry-issues/vertical-integration/.

and export customers. Chicken by-products are utilized by rendering plants.

The U.S. broiler chicken industry has a high degree of vertical integration. This means that broiler processors (integrators) maintain the ownership of broiler chickens at all stages of the broiler supply chain. Approximately 90 percent of broiler chickens are raised under production contracts between broiler processors and broiler growers, about 9 percent of broiler chickens are raised on the farms owned by processors, and the remaining 1 percent is raised by independent chicken growers (National Chicken Council 2022).

Broiler processors own feed mills, hatcheries, and processing plants (Weaver 2014; National Chicken Council 2022). Broiler processors use complex production contracts with broiler growers, according to which broiler growers raise broiler chickens for broiler processors in exchange for a fee. Broiler growers do not own broiler chickens they raise for broiler processors. Production contracts specify responsibilities of broiler processors and broiler growers in great detail (Pilgrim's Pride Broiler Production Agreement 2005; MacDonald 2008; MacDonald 2014). Typically, under production contracts, broiler processors are responsible for providing young chicks, feed, veterinary supplies and services, and transportation of chickens to and from the farms, and they also determine production management practices. Broiler growers are responsible for providing chicken housing facilities, land, labor, utilities, operating expenses, and following production management practices determined by the processor. Because of the widespread use of production contracts, broiler processors are "agricultural producers" who make decisions affecting the quantity of broiler chickens produced at the farm (grow-out) stage of the broiler supply chain.

Feed (corn and soybean meal) is the major input used in broiler production. The feed costs represent approximately 65 to 75 percent of broiler production costs (Weaver 2014). A dramatic increase in feed prices, coupled with the effect of broiler supply and price developments, adversely affected the profitability of broiler processors in the period between 2006 and 2012 (Weaver 2014; *In Re Broiler Chicken Antitrust Litigation* 2019). The prices of corn and soybean meal, the two major feed types used in broiler production, started increasing in 2006 and reached a dramatically high level in the period between 2008 and 2012 (Becker 2008; Schnepf 2008; Weaver 2014), partially contributing to the oversupply of broiler chickens. There was a consistent increase in the quantity of broilers produced, which the market could not absorb at prices profitable for broiler processors. At the same time, due to the 2008–2009 economic recession, broiler demand was declining (Weaver 2014).

The bankruptcy of Pilgrim's Pride in 2009 was evidence of profitability issues in the broiler industry. The company could not maintain a viable profitability level due to increasing feed prices and low chicken prices and filed for bankruptcy. The company was purchased by JBS SA (Chasan and Burgdorfer 2009; Spector, Etter, and Stewart 2009). Changes in the feed cost and wholesale broiler price indices presented in Figure 1 indicate that during the period of 2008 to 2014, the feed cost index level is much higher than the wholesale price index level, which reflects profitability issues in the broiler industry during this period.

A group of the largest broiler processors implemented a series of production cuts at various stages of the broiler supply chain beginning in 2008 to decrease quantities of broilers produced in a period of increasing feed prices and declining demand to maintain a viable profitability level and to avoid financial losses (Weaver 2014; *In Re Broiler Chicken Antitrust Litigation* 2019). The combined market share of the largest broiler processors, who implemented production cuts, was approximately 90 percent (*In Re Broiler Chicken Antitrust Litigation* 2019).

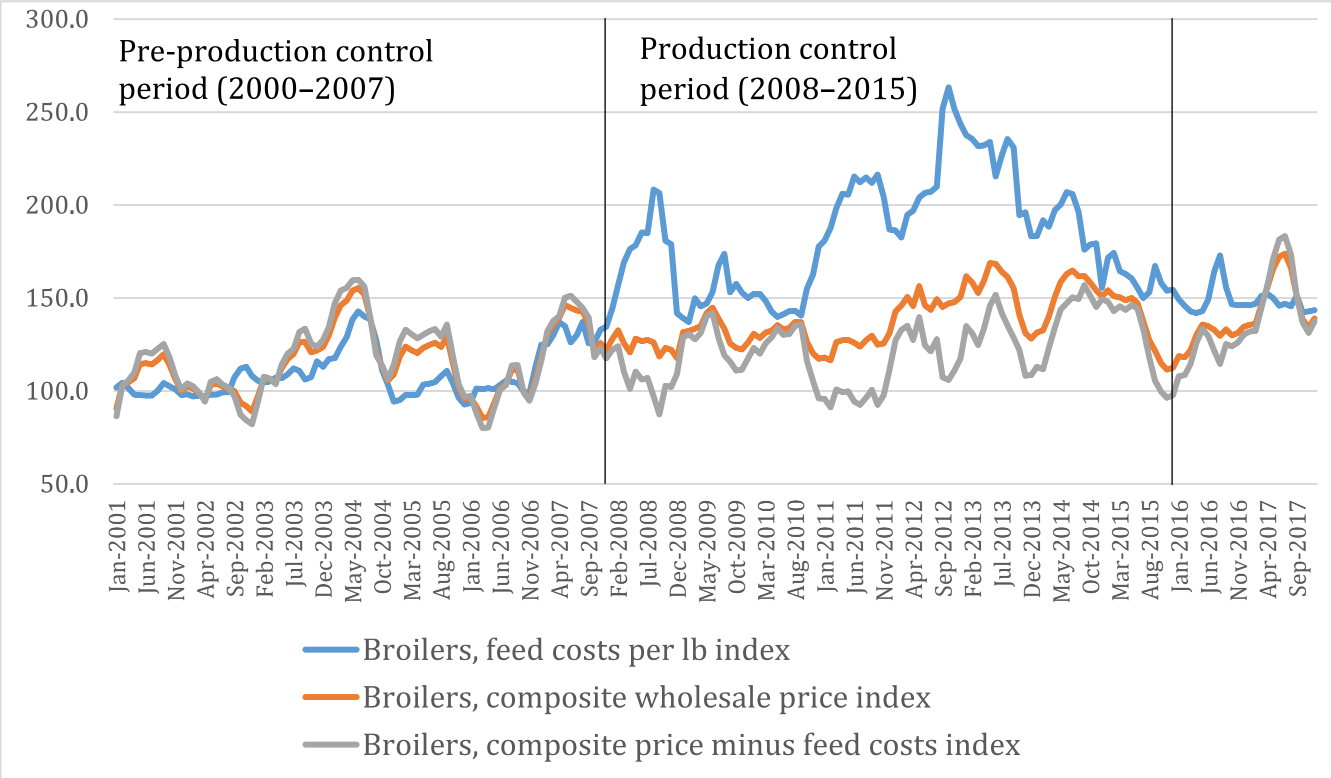

Figure 1. U.S. Broiler Chicken Industry: Monthly Feed Costs Index, Wholesale Price Index, and Wholesale Price Minus Feed Costs Index, 2001—2017

Data source: USDA, Economic Research Service (2022b).

- At the breeder stage, broiler processors decreased the size of breeder flocks (killed broiler breeders prematurely before their optimum age and purchased a smaller quantity of breeder pullets from genetics companies).
- At the breeder stage, broiler processors decreased the size of egg sets (the number of eggs placed in incubators) by breaking eggs and selling them to rendering plants.
- At the hatching stage, broiler processors destroyed newly hatched chicks before delivering them to broiler growers.
- At the grow-out (farm) stage, broiler processors decreased the number of young chicks delivered to contract growers, increased the time period between picking up mature chickens from broiler growers and delivering young chicks to broiler growers.
- At the processing stage, broiler processors decreased the size (weight) of broiler chickens at slaughter by slaughtering them before they reached mature age.
- At the processing stage, broiler processors slowed down and/or closed (temporary or permanently) processing plants.
- Broiler processors increased export of chicks and broiler chickens, which decreased their quantities available for the domestic market.

The largest broiler processors periodically made public statements regarding their intent to implement production cuts. The following excerpts are three examples of these statements.

(1) *"In response, Pilgrim's* ***issued a call to action for its competitors to reduce their production of Broilers to allow prices to recover****. On a January 29, 2008, earnings call, Pilgrim's CFO … said* ***the industry was oversupplying Broilers and it was hurting market prices.*** *[CFO] explained* ***that his company had done its part in 2007 by reducing production 5 percent, so 'the rest [] of the market is going to have to pick-up a fair share in order for the production to come out of the system'****"* (*In Re Broiler Chicken Antitrust Litigation* 2019, paragraph 191).

(2) *"Only a month and a half after installing its new CEO, Pilgrim's* ***again led the charge to cut overall industry supplies****, but this time it backed up its rhetoric with production cuts. On March 12, 2008, Pilgrim's announced a massive closure of its Broiler processing plants. Just five days after taking over the position of Pilgrim's CEO, …,* ***publicly announced the closure of seven Broiler facilities in order to reduce industry oversupply****, stating* ***'we believe [these] actions . . . are absolutely necessary to help bring supply and demand into better balance . . . . That portion of the demand for our products that exists solely at pricing levels below the cost of production is no longer a demand that this industry can continue to supply'****"* (*In Re Broiler Chicken Antitrust Litigation* 2019, paragraph 194).

(3) *"On April 3, 2008, Fieldale Farms* ***announced a 5 percent production cut****. In connection with the cut, Executive Vice President … commented that* ***Fieldale has had trouble passing on cost increases to both foodservice and retail customers****.* ***'Every time we try [to increase prices], one of our competitors comes in with a price lower than our previous price,'*** *…... Fieldale, which has been absorbing feed-cost increases, hopes its move will help ease continuing price pressure.* ***'We can't sell [some of] the chickens at a price higher than the cost,'*** *….* ***'We're hoping this cut puts supply and demand back into better balance'****"* (*In Re Broiler Chicken Antitrust Litigation* 2019, paragraph 195).

Table 3 presents data on yearly broiler production, wholesale prices, percentage changes in the production and price, and price flexibilities for the period of 2000–2015 (Figure 2 depicts production and prices).[6] In the pre-production control period (2000–2007), all percentage changes in broiler production are positive, meaning that in this period broiler production was increasing.[7] This consistent increase in the quantity of broilers produced each year might have contributed to the oversupply (overproduction) of broilers and low wholesale broiler prices not being profitable for broiler processors.

In the production control period (2008–2015), percentage changes in broiler production are both positive and negative. The decreases in broiler production are observed only in 2 years: -3.78 percent in 2009 and -0.44 percent in 2012. These decreases in yearly production likely reflect the effects of production cuts, given that broiler processors implementing production cuts controlled approximately 90 percent of the wholesale broiler market. The increases in broiler production are in the range of 0.79 percent in 2011 to 3.94 percent in 2010. The percentage increases in broiler production might also reflect the effects of production cuts, in which case the growth of broiler production was slowed down.

[6] Nominal wholesale prices of broiler chickens (these are actual market prices that are not adjusted for inflation) are used in the empirical analysis presented in the case study. A discussion of the rationale for using nominal wholesale prices as opposed to real wholesale prices is discussed in Appendix I. The latter also presents a descriptive statistical analysis of real wholesale prices.

[7] The total broiler chicken production each year is affected by the number of broiler chickens slaughtered and the weight of each broiler chicken.

Table 3. The U.S. Broiler Chicken Production, Wholesale Prices, and Price Flexibilities, 2000—2015

Year	Broiler Production (Q)	Wholesale Broiler Price (P)	Change in Broiler Production	Change in Wholesale Broiler Price	Broiler Price Flexibility
	Million pounds	Cents per pound	Percent	Percent	$\frac{\%\ change\ in\ P}{\%\ change\ in\ Q}$
Pre-Production Control Period (Pre-PC Period): 2000–2007					
2000	30,209.0	53.54			
2001	30,938.0	62.04	2.41	15.87	6.6
2002	31,895.0	55.95	3.09	-9.81	**-3.2**
2003	32,398.6	65.65	1.58	17.34	11.0
2004	33,699.0	76.70	4.01	16.82	4.2
2005	34,986.0	67.69	3.82	-11.74	**-3.1**
2006	35,119.7	56.28	0.38	-16.86	**-44.1**
2007	35,772.2	76.22	1.86	35.44	19.1
Production Control Period (PC Period): 2008–2015					
2008	36,511.5	71.16	2.07	-6.64	**-3.2**
2009	35,130.8	75.50	-3.78	6.09	**-1.6**
2010	36,515.1	74.32	3.94	-1.56	**-0.4**
2011	36,804.4	71.46	0.79	-3.85	**-4.9**
2012	36,643.0	84.53	-0.44	18.29	**-41.7**
2013	37,425.3	88.30	2.13	4.47	2.1
2014	38,152.5	86.89	1.94	-1.60	**-0.8**
2015	39,619.8	77.33	3.85	-11.01	**-2.9**

Note: Data source for yearly broiler production and monthly wholesale prices is USDA, Economic Research Service (2022a, 2022b). Yearly prices are calculated by the author using monthly prices reported in USDA, Economic Research Service (2022b).

The broiler price flexibilities vary in magnitude over time.[8] The majority of price flexibilities with the expected negative sign are in the range of -1 to -5 in both periods. For example, a price flexibility calculated for 2009 is -1.6, indicating that a 1 percent decrease in broiler production in the period of 2008–2009 caused a 1.6-percent increase in the wholesale price of broilers in 2009.

[8] Price flexibilities are elasticities associated with price-dependent (inverse) demand functions (Moore 1919; Houck 1965; Hudson 2007). Price flexibility indicates a percentage increase (decrease) in product price, which follows a 1-percent decrease (increase) in product quantity demanded. Theoretically, price flexibilities are expected to be negative. The positive values for price flexibilities reported for selected years are not as expected. These positive values may reflect the effects of changes in a variety of factors affecting prices and quantities of broiler chickens: prices and quantities of products-substitutes (beef and pork), consumer income, production costs (for example, feed prices and fees paid to contract broiler growers), and new production technologies leading to increasing productivity (increasing chicken weight). Appendix II discusses price flexibilities in greater detail.

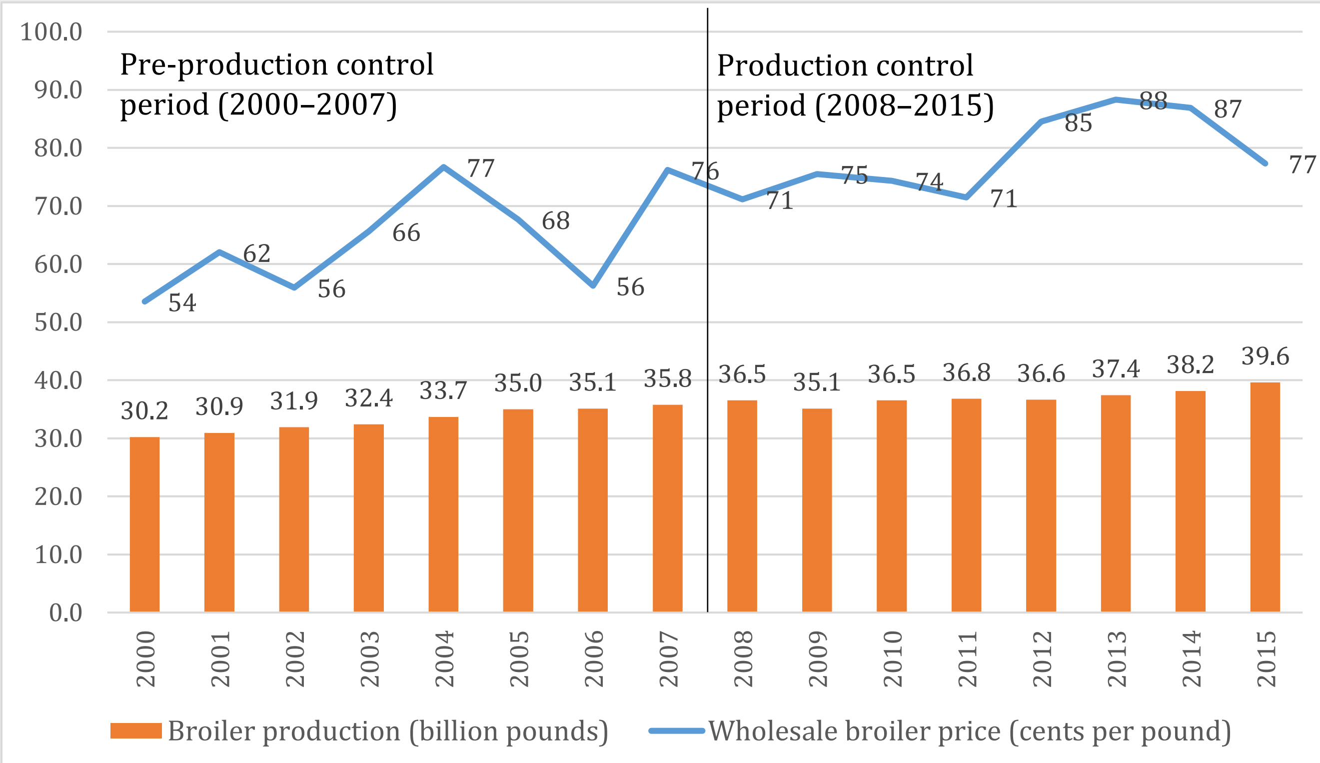

Figure 2. The U.S. Broiler Chicken Production and Wholesale Prices (Yearly Data), 2000–2015

Data source for yearly broiler production and monthly wholesale prices is USDA, Economic Research Service (2022a, 2022b). Note: Yearly prices are calculated by the author using monthly prices reported in USDA, Economic Research Service (2022b).

The absolute value of the majority of calculated broiler price flexibilities is greater than one, reflecting inelastic demand for broilers. Because a percentage change in broiler price is greater than a percentage change in broiler quantity, broiler processors would benefit from decreasing the broiler quantity produced even by a small percent, which would cause the wholesale broiler price to increase by a greater percent.

3.2 Hogs and Pork

The production process of hogs slaughtered to manufacture pork products includes four stages (McBride and Key 2013; Giamalva 2014; Pork Checkoff 2022a).

1. Breeding and gestation stage: female hogs are bred and cared for during gestation period (3 months, 3 weeks, and 3 days).
2. Farrowing stage: baby pigs are born and cared until weaning, when they are 3 weeks of age and weigh 13 to 15 pounds (3 weeks).
3. Nursery stage: piglets are cared for after weaning until they reach weight of about 50 to 60 pounds (6 to 8 weeks).
4. Finishing stage: hogs are fed until they reach a slaughter weight of approximately 280 pounds (16 to 17 weeks).

Hog producers (farmers) are categorized based on the number of hog production stages taking place at the same operation: farrow-to-finish (all four stages), farrow-to-feeder (stages #1–3), feeder-to-finish (stage #4), wean-to-feeder (stage #3), and farrow-to-wean (stages #1–2; McBride and Key 2013).

While in the past, most hog producers were farrow-to-finish operations, the recent trend is for hog producers to specialize on a single stage (McBride and Key 2013).

As for the decision-making process affecting the quantity of hogs produced, both hog producers and pork processors make decisions affecting this quantity. Traditionally, hog producers as hog owners, who sell their hogs in the spot market or use marketing contracts,[9] have been making decisions affecting hog quantity produced. In recent decades, the use of production contracts between hog producers and pork processors has increased (McBride and Key 2013).

Pork processors use complex production contracts with hog producers, according to which hog producers raise (feed and finish) pigs/hogs for pork processors in exchange for a fee. Consequently, pork processors make decisions that affect hog quantities produced by hog producers under these contracts. Hog producers do not own pigs/hogs they raise for pork processors. Production contracts specify responsibilities of pork processors and hog producers in great details (Swinton and Martin 1997; McBride and Key 2013; Lawrence et al. 2019). Typically, under production contracts pork processors are responsible for providing pigs, feed, veterinary and medical supplies and services, and transportation of pigs to and from the farms, and they also determine production management practices. Hog producers are responsible for providing hog housing facilities, land, labor, utilities, operating expenses, and following production management practices determined by the processor.

The hog quantity produced each year affects hog prices, which are input prices or costs for pork processors who purchase hogs from hog producers using the spot market or marketing contracts. Consistent with agricultural production and price cycle, in the years of small hog production, hog prices tend to be high, and in the years of large hog production, hog prices tend to be low. The hog production and price cycle lasts approximately 3 to 4 years (Kohls and Uhl 2002; Norwood and Lusk 2008), and it can be briefly described as follows. Assume that in the past year hog quantity available in the market was small and hog prices were high. In the current year, hog producers who are already in business plan to increase hog quantity produced by increasing (expanding) their herd sizes, and some hog producers re-enter the industry looking to capture existing profits. To increase their herd size, hog producers must retain female hogs from the market for breeding purposes, which further decreases the current quantity of hogs marketed and consequently further pushes the current hog price up.

In the next few years, after the expansion, the quantity of hogs supplied to the market increases, which will decrease hog prices. In response to low hog prices, there will be a decrease in hog quantity produced and marketed. Many hog producers will decrease their herd sizes in response to low hog prices. Some hog producers will liquidate their herds by exiting the industry. This contraction in hog production would lead to higher hog prices in the future.

Feed (corn and soybean meal) is the major input used in hog production. Feed costs account for more than 65 percent of all pork production expenses (Pork Checkoff 2022b). A dramatic increase in feed prices, coupled with the effect of hog production and price developments, adversely affected the profitability of pork processors in 2009 (Giamalva 2014; *In Re Pork Antitrust Litigation* 2020). The prices of corn and soybean meal, the two major feed types used in hog production, started increasing dramatically in 2008 (Becker 2008; Schnepf 2008). Pork processors, who used production contracts with hog producers, had to pay higher feed prices. Pork processors, who purchased their hogs using the spot market and/or marketing contracts, had to pay higher hog prices, which were due to higher feed prices.

The largest pork processors implemented a series of production cuts at various stages of the pork supply chain beginning in 2009 to decrease the quantities of pork produced in the period of increasing feed prices and weakening demand to maintain a viable profitability level and to avoid financial losses (Giamalva 2014; *In Re Pork Antitrust Litigation* 2020). The combined market share of the largest pork

[9] Under a marketing contract, hog producers own the hogs they raise, to be sold to processors later. Consequently, hog producers are responsible for making production and marketing decisions.

processors, who implemented production cuts, was approximately 80 percent (*In Re Pork Antitrust Litigation* 2020).

- At the breeding stage, pork processors decreased the size of breeding stocks and decreased the number of female hogs. Because of the increasing use of production contracts, pork processors had some control over the breading stage of the pork supply chain.
- At the production stage, pork processors increased the use of production contracts, by which they had increased control over the quantity of hogs procured under these contracts and consequently over the quantity of pork they produced.
- At the production stage, pork processors decreased the number of hogs by implementing partial liquidations of their herds.
- At the processing stage, pork processors controlled hog slaughter rates and decreased the utilization of plant capacity (i.e., decreased the quantity of hogs processed at a plant).
- Pork processors increased pork export volume, which decreased the quantity of pork available for the domestic market.

The largest pork processors periodically made public statements regarding their intent to implement production cuts. The following excerpts are three examples of these statements.

(1) *"In May 2009, …, the CEO and President of Smithfield, stated: In terms of chronology of how I say we proactively managed this business, in February of last year—**February of '08**, not February of '09**—we made the decision with the over-supply of livestock to take the leadership position and start reducing our sow herds because we saw the overproduction and the oversupplies of the hogs into the market, which was driving our hog market down. We started a reduction of 50,000 sows and 1 million of our 18 million pigs, we started taking out of the system**"* (*In Re Pork Antitrust Litigation* 2020, paragraph 138).

(2) *"In June 2009, the CEO of Smithfield stated that the **current cuts were not enough and more were needed to 'fix' the hog industry and that '[s]omebody else has got to do something'**: One of the things that we're doing is managing what you can do and the 3 percent relates to one of our operations and it's our—I'll tell you, it's our Texas operation that sells pigs to Seaboard. Seaboard knows that. . . . **That 3 percent, let me say that, our 3 percent will not fix the hog industry. That part I'm confident of. Somebody else has got to do something.** We cut 13 percent. The first 10 percent didn't fix it. I don't think us going from 10 to 13 is going to fix the hog business"* (*In Re Pork Antitrust Litigation* 2020, paragraph 140).

(3) *"In August of 2009, Tyson Foods, Inc. Chief Operating Officer, …, confirmed: Hog supplies will be down in Q4 year over year but still adequate. **We do expect to see liquidation accelerate and pork production decrease into 2010 and beyond to improve producer profitability.** We will continue to watch forward hog supplies to drive more exports, monitor demand, focus on cost, mix, and pricing to generate revenue"* (*In Re Pork Antitrust Litigation* 2020, paragraph 142).

Table 4 presents data on yearly pork production, wholesale prices, percentage changes in the production and price, and price flexibilities for the period of 2000–2017 (Figure 3 depicts production and prices).[10] In the pre-production control period (2000–2008), all percentage changes in pork production are positive, indicating that in this period pork production was increasing.[11] This consistent increase in quantity of pork produced each year might have contributed to the oversupply (overproduction) of pork and low wholesale pork prices not profitable for pork processors.

Table 4. The U.S. Pork Production, Wholesale Prices, and Price Flexibilities, 2000—2017

Year	**Pork Production (Q)**	**Wholesale Pork Price (P)**	**Change in Pork Production**	**Change in Pork Price**	**Pork Price Flexibility**
	Million pounds	Cents per pound	Percent	Percent	$\frac{\%\ change\ in\ P}{\%\ change\ in\ Q}$
Pre-Production Control Period (Pre-PC Period): 2000–2008					
2000	18,952.0	64.07			
2001	19,160.0	66.83	1.10	4.31	3.9
2002	19,685.0	53.49	2.74	-19.96	**-7.3**
2003	19,966.0	58.87	1.43	10.05	7.0
2004	20,529.0	73.53	2.82	24.90	8.8
2005	20,705.0	69.84	0.86	-5.02	**-5.9**
2006	21,073.5	67.62	1.78	-3.17	**-1.8**
2007	21,962.1	67.54	4.22	-0.13	**-0.03**
2008	23,366.6	69.24	6.40	2.52	0.4
Production Control Period (PC Period): 2009–2017					
2009	23,020.4	58.13	-1.48	-16.05	10.8
2010	22,455.5	81.25	-2.45	39.78	**-16.2**
2011	22,775.4	93.69	1.42	15.31	10.7
2012	23,267.9	84.54	2.16	-9.77	**-4.5**
2013	23,204.2	91.69	-0.27	8.45	**-30.9**
2014	22,858.0	110.10	-1.49	20.08	**-13.5**
2015	24,516.8	78.96	7.26	-28.28	**-3.9**
2016	24,956.6	78.36	1.79	-0.77	**-0.4**
2017	25,597.6	84.02	2.57	7.22	2.8

Note: Data source for yearly pork production and monthly pork prices is USDA, Economic Research Service (2022a, 2022b). Yearly prices are calculated by the author using monthly prices reported in USDA, Economic Research Service (2022b).

[10] Nominal wholesale prices of pork (these are actual market prices that are not adjusted for inflation) are used in the empirical analysis presented in the case study. A discussion of the rationale for using nominal wholesale prices as opposed to real wholesale prices is discussed in Appendix I. The latter also presents a descriptive statistical analysis of real wholesale prices.

[11] The total pork production each year is affected by the number of hogs slaughtered and the weight of each hog.

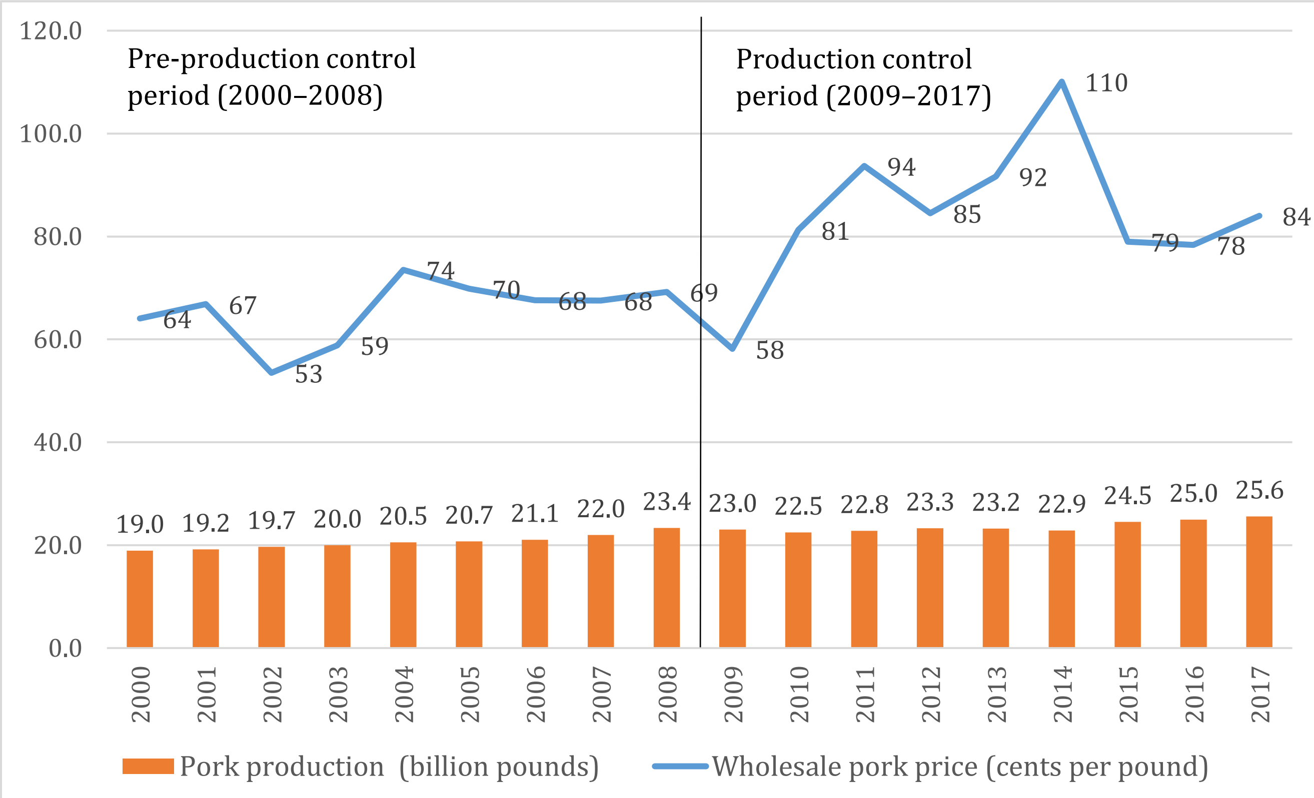

Figure 3. The U.S. Pork Production and Wholesale Prices (Yearly Data), 2000–2017

Data source for yearly pork production and monthly wholesale prices is USDA, Economic Research Service (2022a, 2022b).
Note: Yearly prices are calculated by the author using monthly prices reported in USDA, Economic Research Service (2022b).

In the production control period (2009–2017), the percentage changes in pork production are both positive and negative. The decreases in pork production are in the range of -0.27 percent in 2013 to -2.45 percent in 2010. These decreases in yearly production might reflect the effects of production cuts, given that pork processors who implemented production cuts controlled approximately 80 percent of the wholesale pork market. The increases in pork production are in the range of 1.42 percent in 2011 to 7.26 percent in 2015. The percentage increases in pork production might also reflect the effects of production cuts, in which case the growth of production was slowed down.

The pork price flexibilities vary in magnitude over time.[12] The majority of price flexibilities with the expected negative sign are in the range of -1 to -7. For example, a price flexibility calculated for 2012 is -4.5, indicating that a 1 percent increase in pork production in the period of 2011–2012 caused a 4.5 percent decrease in the wholesale price of pork. The absolute value of the majority of calculated pork price flexibilities is greater than one, reflecting inelastic demand for pork. Because a percentage change in pork price is greater than a percentage change in pork quantity, pork processors would benefit from decreasing

[12] Price flexibilities are elasticities associated with price-dependent (inverse) demand functions (Moore 1919; Houck 1965; Hudson 2007). Price flexibility indicates a percentage increase (decrease) in product price, which follows a 1-percent decrease (increase) in product quantity demanded. Theoretically, price flexibilities are expected to be negative. The positive values for price flexibilities reported for selected years are not as expected. These positive values may reflect the effects of changes in a variety of factors affecting prices and quantities of pork: prices and quantities of products-substitutes (chicken and beef), consumer income, production costs (for example, feed prices, hog prices, and fees paid to contract hog growers), new production technologies leading to increasing productivity (increasing hog weight). Appendix II discusses price flexibilities in greater detail.

the pork quantity produced even by a small percent, which would cause the wholesale pork price to increase by a greater percent.

4 Theoretical Frameworks

This section presents a graphical analysis of economic models explaining the profit-maximizing behavior of industries exercising seller market power and perfectly competitive industries, which may be used to evaluate conduct and performance of the broiler and pork industries in the analyzed setting.[13] In the analysis presented in this section it is assumed that broiler and pork processors are integrators, who use production contracts according to which they are responsible for incurring feed costs.

4.1 The U.S. Broiler Chicken and Pork Industries as Classic Oligopolies

Based on the number of firms operating in the U.S. broiler and pork industries and other industry characteristics (product homogeneity, inelastic demand, and high barriers to entry), these industries are classic oligopolies—market structures with a relatively small number of sellers. To understand their seller market power, oligopolies are evaluated relative to a perfectly competitive industry.

Figure 4 is a graphical representation of an economic model explaining the profit-maximizing behavior of firms in perfectly competitive industries and industries with seller market power (oligopoly and monopoly). The inverse demand curve labeled as "P" is a graphical representation of the inverse (price-dependent) demand function at the wholesale (processing) stage of the broiler and pork supply chains. The marginal cost curve labeled as "MC" is a graphical representation of a constant marginal cost function. The processors make decisions on the output quantity to produce (output: broiler chickens and pork products). The output price is a function of the output quantity.

To maximize its profit, an oligopolistic industry produces output quantity (Qo), which is smaller than output quantity produced by a perfectly competitive industry (Qc). The output price in the oligopolistic industry (Po) is higher than the output price in a perfectly competitive industry (Pc), and the oligopolistic industry profit is positive (Po-MC > 0). If firms operating in the oligopolistic industry form an output price-fixing cartel (i.e., engage in a price-fixing conspiracy),[14] to maximize their *joint* profit, they would aim to decrease output quantity (Qo) possibly to output quantity produced by a monopoly (Qm). As a result, the oligopoly price (Po) would approach the monopoly price (Pm), and the industry profit increases by Pm-Po in $ per unit and by (Pm-Po)*Qm in total $, which is a cartel overcharge.[15]

The cartel overcharge expressed in total $ is the shaded rectangle in Figure 4. The cartel overcharge is the basis for damages that direct buyers of broilers and pork products aim to recover during antitrust litigations.[16] In summary, the cartel effects on buyers of the cartelized product are a decrease in the product quantity available in the market, an increase in this product price, and a

[13] The teaching note's Appendix I presents mathematical formulations of the profit-maximization problems for a monopolist, an oligopolist, and a perfectly competitive firm, which can be used if this case study is used in the upper level undergraduate and graduate courses. Alternatively, standard profit-maximization problems for monopoly and oligopoly explained in classic textbooks in the areas of microeconomics, industrial organization, and agricultural markets and prices can be used to illustrate mathematical formulations of these economic models (Besanko and Braeutigam 2002; Carlton and Perloff 2005; Hudson 2007; Norwood and Lusk 2008).

[14] A cartel is a group of firms, who produce and sell the same or similar products (the firms are competitors), which aims to affect product quantities and/or prices to increase the joint profit of cartel participants. Cartels are typically organized in concentrated (oligopolistic) industries. A classic output price-fixing cartel would aim to act as a multi-plant monopolist (Besanko and Braeutigam 2002).

[15] It is often assumed that oligopolists have incentives to collude to increase their joint profit. Theoretically, an oligopolistic conduct can result in a variety of market outcomes (output price-quantity combinations) ranging from perfect competition to an oligopoly and even to a monopoly, which can be reached without firms having agreements violating Section 1 of the Sherman Act (Baker 1993; Besanko and Braeutigam 2002; Carlton and Perloff 2005; Hovenkamp 2005).

[16] Buyers purchasing broilers and pork products directly from processors are entitled to recover treble damages under the Clayton Act (1914), a federal law.

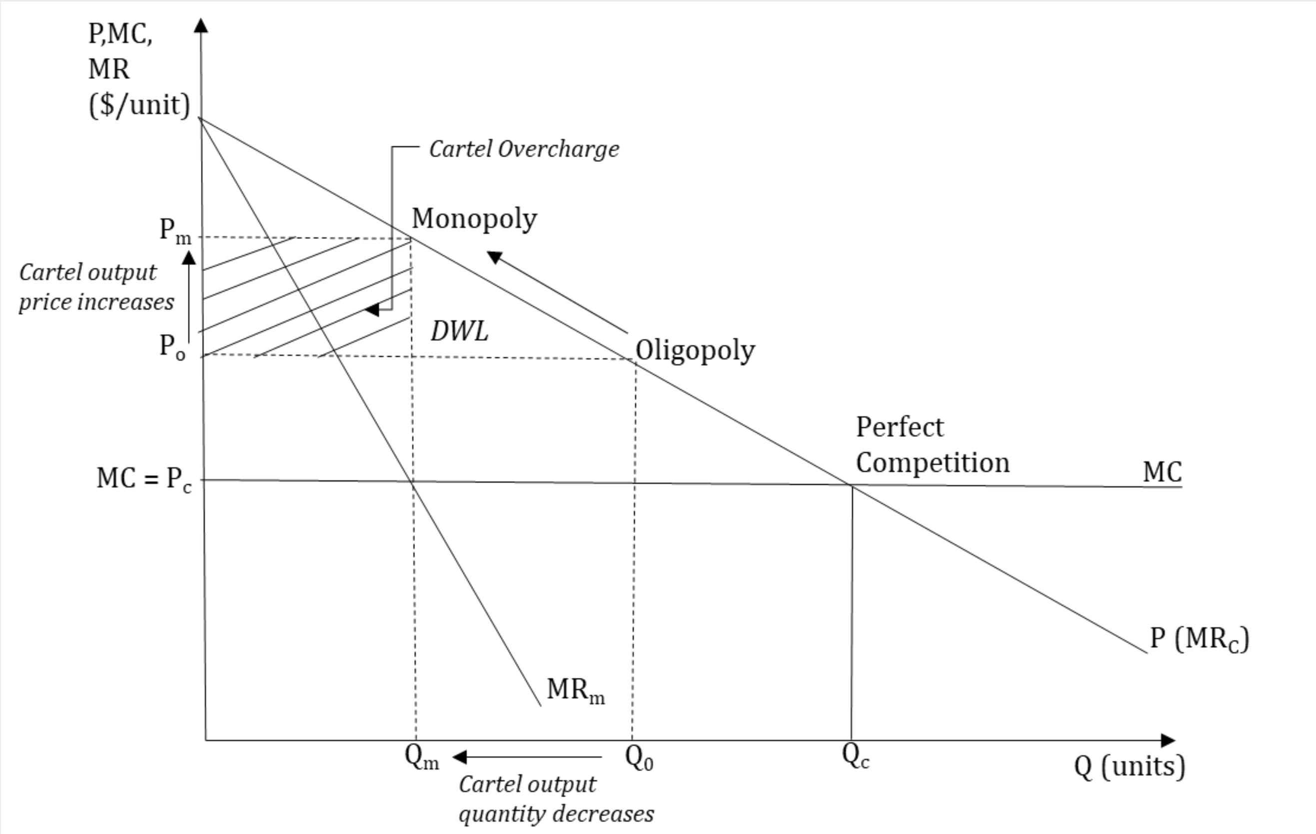

Figure 4. The U.S. Broiler and Pork Industries as Classic Oligopolies Acting as Output Price-Fixing Cartels: Output Quantity and Output Price Effects

deadweight loss. The latter is the "DWL" triangle in Figure 4. Because of the deadweight loss there are buyers who do not purchase the product because of higher prices.

4.2 The U.S. Broiler Chicken and Pork Industries as Perfectly Competitive Industries Facing Increasing Marginal Cost

A description of the nature of agricultural supply and profitability issues in the broiler and pork industries presented in the previous section may suggest that these industries behaved as perfectly competitive industries.

Figure 5 is a graphical representation of an economic model explaining the profit-maximizing behavior of a perfectly competitive industry facing increasing marginal cost. The original scenario presented in Figure 5 is the one for the period prior to the implementation of production cuts in the broiler and pork industries ("Perfect Competition" at the intersection of the inverse demand and marginal cost curves). The output price-quantity combination corresponding to the original scenario is Qc and Pc, and the industry profit is zero (Pc = MC or Marginal Profit = Pc – MC = 0).

The implementation of production cuts by broiler and pork processors coincided with a dramatic increase in feed prices (corn and soybean meal prices). The feed price is a major variable cost component for broiler and pork processors. An increase in feed prices would represent an upward parallel shift of the marginal cost curve: this is a new scenario with the increased marginal cost. The original marginal cost curve labeled as MC in Figure 5 shifts upward to become the new marginal cost curve labeled as MC^{new}. Assuming the output price-quantity relationship (demand) does not change, an increase in

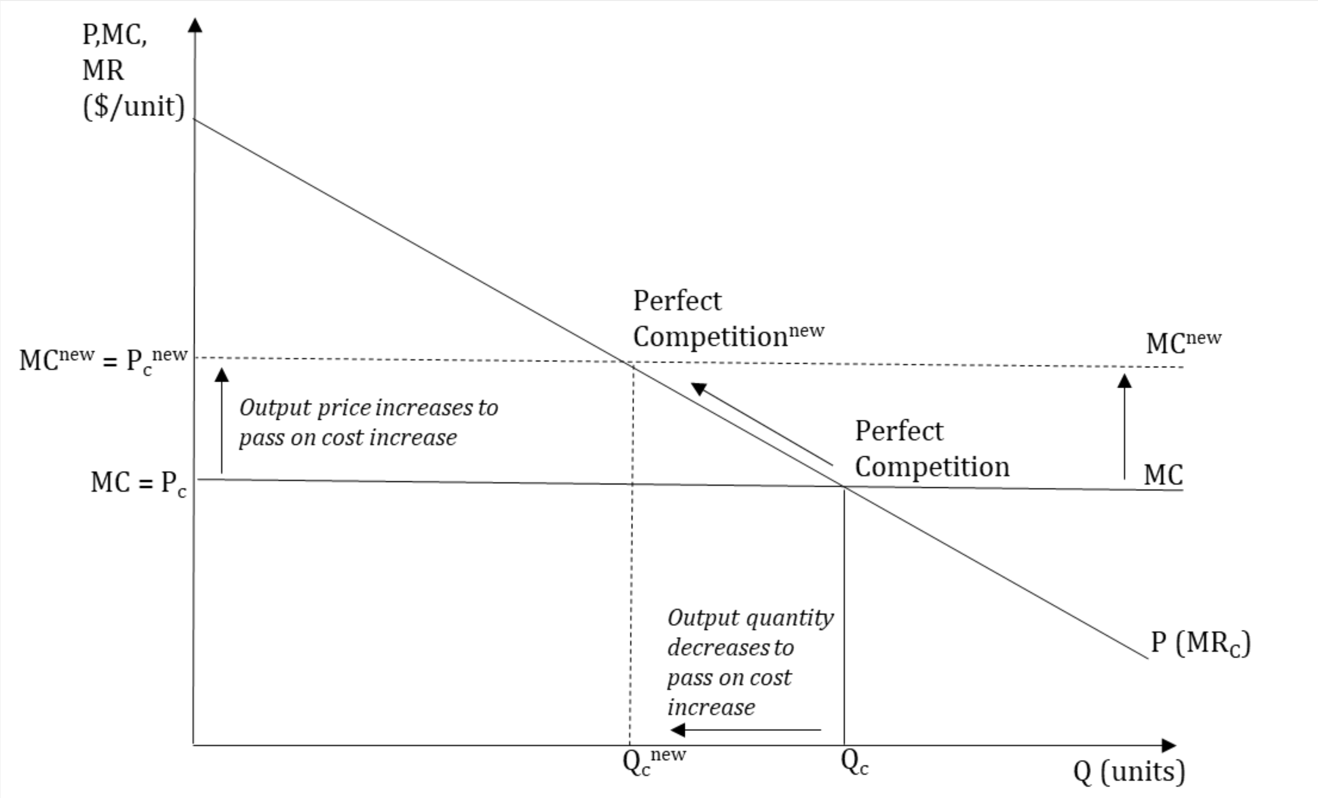

Figure 5. The U.S. Broiler and Pork Industries as Perfectly Competitive Industries Facing Increasing Marginal Cost (Increasing Feed Prices): Output Quantity and Output Price Effects

marginal cost would require processors to decrease output quantity produced to maintain the profitability level of the original perfectly competitive industry scenario. The processors have to decrease output quantity produced to pass the cost increase on to buyers, which would result in a higher output price. Consequently, the processors decrease output quantity from Qc to Qc^{new}, and output price increases from Pc to Pc^{new}. The overall industry profit in the new scenario is zero ($Pc^{new} = MC^{new}$ or Marginal Profit = $Pc^{new} - MC^{new} = 0$).

Figure 5 indicates that the industry profitability is determined by the output price, marginal cost, and output quantity. If broiler and pork processors do not decrease output quantity in response to the increased marginal cost, they would be in an agricultural oversupply (overproduction) scenario, where the original output price Pc is below the new marginal cost MC^{new} (at the original scenario's output quantity Qc). Consequently, the industry profit would be negative, because at the original output quantity Qc the inverse demand curve is below the new marginal cost curve ($Pc < MC^{new}$ or Marginal Profit = $Pc - MC^{new} < 0$).

Figure 6 is a modified version of Figure 5, where the Figure 5's output price and quantity corresponding to the original scenario are labeled as the ones corresponding to the oversupply scenario, Qo and Po. In the oversupply scenario, the profit is negative (at Qo, Marginal Profit = $Po - MC^{new} < 0$); broiler and pork processors incur losses. Figures 5 and 6 may explain economic rationale for implementing production cuts in the broiler and pork industries, assuming that they behave as perfectly competitive industries.

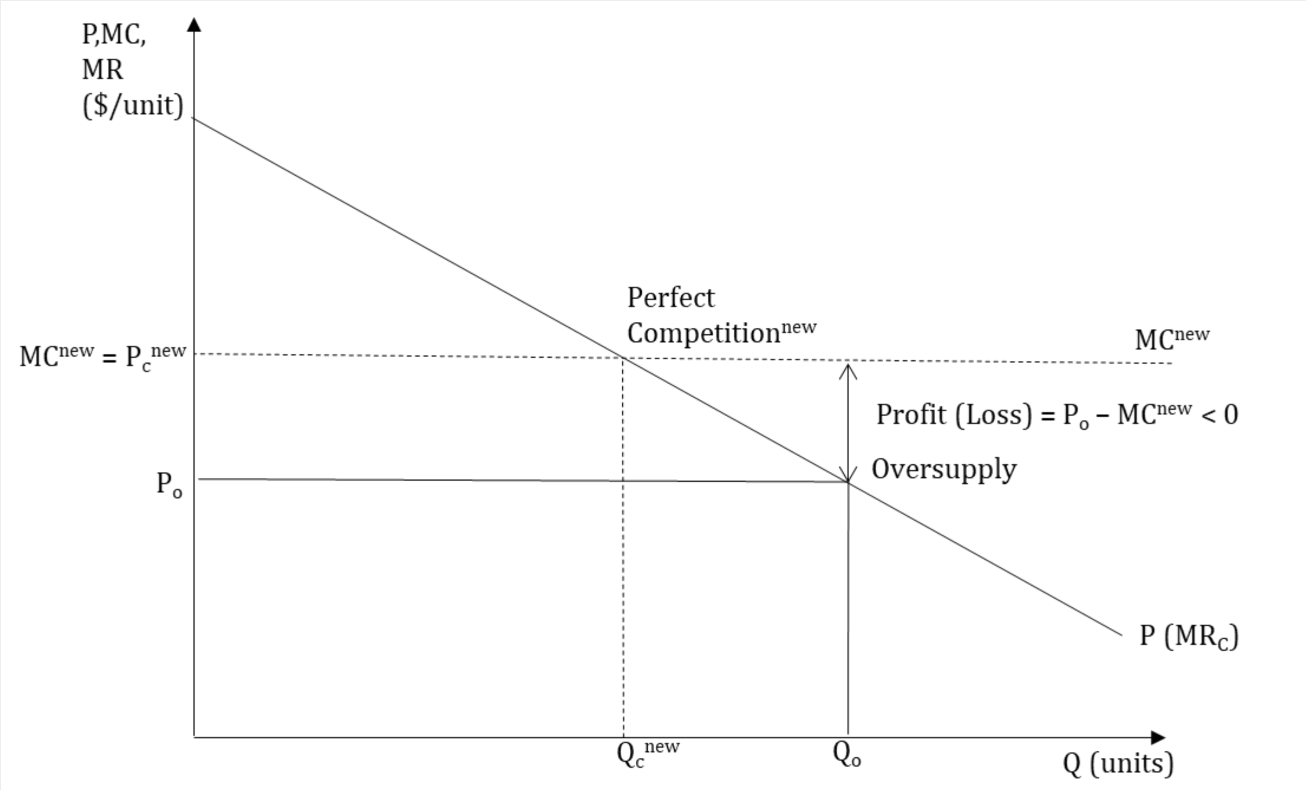

Figure 6. The U.S. Broiler and Pork Industries as Perfectly Competitive Industries Facing Increasing Marginal Cost (Increasing Feed Prices): Output Quantity, Output Price, and Industry Profit (Loss) in the Oversupply Scenario

5 Market and Price Analysis

This section presents a descriptive statistical analysis of the economic variables characterizing market and price behavior in the U.S. broiler and pork industries in the two periods of interest: the pre-production control period (Pre-PC period) and the production control period (PC period).[17] The analyzed variables include product quantities (production, domestic consumption, and export), wholesale prices, and margins (or corresponding indices). The analysis is conducted at the wholesale (processing) stage of the broiler and pork supply chains. The variables are collected from USDA Economic Research Service databases (U.S. Department of Agriculture, Economic Research Service 2022a, 2022b, 2022c).[18] The analysis objective is to identify and evaluate changes in the level and volatility of the analyzed economic variables between the two periods of interest by calculating their averages and coefficients of variation for the two periods,[19] as well as changes in the averages and coefficients of variation between the two

[17] In the U.S. broiler industry, the Pre-PC period is 2000–2007, and the PC period is 2008–2015. The beginning of the PC period is the beginning date of the alleged price-fixing conspiracy stated in *In Re Broiler Chicken Antitrust Litigation* (2019). The end of the PC period is the year prior to the year when antitrust lawsuits were filed against the largest broiler processors. The U.S. pork industry: the Pre-PC period is 2000–2008, and the PC period is 2009–2017. The beginning of the PC period is the beginning date of the alleged price-fixing conspiracy stated in *In Re Pork Antitrust Litigation* (2020). The end of the PC period is the year prior to the year when antitrust lawsuits were filed against the largest pork processors. The Pre-PC period in the case of both industries is selected such that its length is equal to the PC period length.

[18] The teaching note's Appendix II provides a detailed description of economic variables and data sources.

[19] Coefficient of variation (CV) is selected to measure the volatility of the analyzed variables. While there are other measures of volatility available, for example standard deviation and variance, an advantage of the coefficient of variation is that it measures

periods. The evaluation of changes in the volatility of the analyzed economic variables would provide evidence on whether by implementing agricultural supply control practices the broiler and pork industries were able to effectively manage agricultural supply and price volatility to stabilize their agricultural production conditions.

5.1 U.S. Broiler Chicken Industry

Table 5 presents descriptive statistics on broiler production, export, and availability for domestic consumption in the Pre-PC and PC periods.[20] The yearly average broiler production is 33,127 million pounds in the Pre-PC period, and it increases to 37,100 million pounds in the PC period (or by ____ percent).[21] The yearly average broiler export is 5,162 million pounds in the Pre-PC period, and it increases to 6,970 million pounds in the PC period (or by ____ percent).

The yearly average quantity of broiler meat available for domestic consumption is 27,833 million pounds in the Pre-PC period, and it increases to 30,016 million pounds in the PC period (or by ____ percent). The yearly average quantity of broiler meat available per capita is 95 pounds in the Pre-PC period, and it increases slightly to 96 pounds in the PC period (or by _____ percent). As indicated by changes in the coefficients of variation, the volatility of all quantity-related variables decreases in the PC period, as compared with the Pre-PC period.

Table 5. The U.S. Broiler Chicken Industry: Yearly Broiler Production, Export, and Availability, 2000—2015

Average/ Coefficient of Variation (CV)	Broiler Production	Broiler Export	Broiler Availability	Broiler Availability per Capita
	Million pounds	Million pounds	Million pounds	Pounds
Pre-Production Control Period (Pre-PC Period): 2000–2007				
Average	33,127	5,162	27,833	95
CV	0.06	0.08	0.07	0.05
Production Control Period (PC Period): 2008–2015				
Average	37,100	6,970	30,016	96
CV	0.04	0.05	0.05	0.03
Change: PC Period, Relative to Pre-PC Period				
Average	3,973	_____	2,183	_____
Average (percentage change)	12.0	_____	7.8	_____
CV	-0.03	_____	-0.02	_____
CV (percentage change)	-43	_____	-32	_____

Source: USDA, Economic Research Service (2022a).
Note: Students should calculate changes in the averages and coefficients of variation for broiler export and availability per capita and record their answers in cells with missing answers (Question 6.1).

the standard deviation relative to the mean of the analyzed variable: $CV = \frac{Standard\ Deviation}{Mean}$. The coefficient of variation can also be expressed in the percentage form.

[20] The results reported in Tables 5–8 were generated in Excel. If selected calculations are reproduced using a calculator, results might be slightly different than those reported here.

[21] Tables 5–8 have cells with missing answers. Students should calculate changes in the averages and coefficients of variation and record their answers in the cells with missing answers. After relevant calculations are performed and the answers are recorded in the tables, students should record *percentage* changes in the averages of the analyzed variables between the two periods in the parentheses in the text of the case study (Sections 5.1 and 5.2). Alternatively, instructors might prefer to share with students Tables 5–8 with all answers recorded or an Excel file with relevant calculations, which are included in the teaching note.

Table 6 presents descriptive statistics on the three indices characterizing changes in the broiler feed costs, wholesale price, and margin (wholesale price minus feed costs) in the two periods of interest. Figure 1 depicts these three indices for the period of 2001–2017.

Table 6. The U.S. Broiler Chicken Industry: Monthly Feed Costs Index, Wholesale Price Index, and Wholesale Price Minus Feed Costs (Margin) Index, 2001—2015

Average/Coefficient of Variation (CV)	Feed Costs per Pound *Index*	Wholesale Price *Index*	Wholesale Price Minus Feed Costs *Index*
Pre-Production Control Period (Pre-PC Period): 2001–2007			
Average	109.75	115.40	117.40
CV	0.12	0.15	0.17
Production Control Period (PC Period): 2008–2015			
Average	183.46	137.77	121.61
CV	0.17	0.11	0.15
Change: PC Period Relative to Pre-PC Period			
Average	______	______	4
Average (percentage change)	______	______	4
CV	______	______	-0.02
CV (percentage change)	______	______	-13.66

Source: USDA, Economic Research Service (2022b).
Note: Students should calculate changes in the averages and coefficients of variation for feed costs index and wholesale price index and record their answers in cells with missing answers (Question 6.2).

The monthly average feed costs index is 110 in the Pre-PC period, and it increases to 183.5 in the PC period (or by ____ percent). The monthly average wholesale price index is 115.4 in the Pre-PC period, and it increases to 138 in the PC period (or by _____ percent). The monthly average margin index is 117.4 in the Pre-PC period, and it increases to 121.6 in the PC period (or by _____ percent). As indicated by changes in the coefficients of variation, the volatility of the feed costs index increases, but the volatility of the wholesale price and margin indices decreases in the PC period, as compared with the Pre-PC period.

Table 7 presents descriptive statistics on the wholesale broiler price for the two periods of interest. The monthly average wholesale broiler price is $0.64 per pound in the Pre-PC period, and it increases to $0.79 per pound in the PC period (or by _____ percent). As indicated by the change in the coefficient of variation, the volatility of this price decreases by 32 percent in the PC period, as compared with the Pre-PC period.

5.2 U.S. Pork Industry

Table 8 presents descriptive statistics on pork production, export, and availability for domestic consumption for the two periods of interest. The yearly average pork production is 20,600 million pounds in the Pre-PC period, and it increases to 23,628 million pounds in the PC period (or by _____ percent). The yearly average pork export is 2,424 million pounds in the Pre-PC period, and it increases to 4,983 million pounds in the PC period (or by _____ percent). The yearly average quantity of pork available

Table 7. The U.S. Broiler Chicken and Pork Industries: Monthly Wholesale Broiler Price, Wholesale Pork Price, and Pork Farm-to-Wholesale Margin, 2000—2017

Average/Coefficient of Variation (CV)	Wholesale Broiler Price	Wholesale Pork Price	Pork Farm-to-Wholesale Margin
	Cents per pound	Cents per pound	Percent of wholesale value
Pre-Production Control Period (Pre-PC Period)	***2000–2007***	***2000–2008***	
Average	64.26	65.67	32.48
CV	0.16	0.13	0.16
Production Control Period (PC Period)	***2008–2015***	***2009–2017***	
Average	78.69	84.53	35.13
CV	0.11	0.18	0.23
Change: PC Period Relative to Pre-PC Period			
Average	14.43	18.86	______
Average (percentage change)	22	29	______
CV	-0.05	0.05	______
CV (percentage change)	-32	40	______

Source: USDA, Economic Research Service (2022b, 2022c).
Note: Students should calculate changes in the average and coefficient of variation for pork farm-to-wholesale margin and record their answers in cells with missing answers (Question 7.2).

Table 8. The U.S. Pork Industry: Yearly Pork Production, Export, and Availability, 2000—2017

Average/Coefficient of Variation (CV)	Pork Production	Pork Export	Pork Availability	Pork Availability per Capita
	Million pounds	Million pounds	Million pounds	Pounds
Pre-Production Control Period (Pre-PC Period): 2000–2008				
Average	20,600	2,424	19,013	65
CV	0.07	0.44	0.02	0.02
Production Control Period (PC Period): 2009–2017				
Average	23,628	4,983	19,370	61
CV	0.05	0.10	0.05	0.04
Change: PC Period, Relative to Pre-PC Period				
Average	3,028	______	358	_____
Average (percentage change)	14.7	______	1.9	_____
CV	-0.02	______	0.03	_____
CV (percentage change)	-31	______	161	_____

Source: USDA, Economic Research Service (2022a).
Note: Students should calculate changes in the averages and coefficients of variation for pork export and availability per capita and record their answers in cells with missing answers (Question 7.1).

for domestic consumption is 19,013 million pounds in the Pre-PC period, and it increases to 19,370 million pounds in the PC period (or by _____ percent). The yearly average quantity of pork available per capita is 65 pounds in the Pre-PC period, and it decreases to 61 pounds in the PC period (or by _____ percent). As indicated by changes in the coefficients of variation, the volatility of pork production and export decreases, but the volatility of pork quantity available for domestic consumption increases in the PC period, as compared with the Pre-PC period.

Table 7 presents descriptive statistics on wholesale pork price and farm-to-wholesale margin for the two periods of interest. The monthly average wholesale pork price is $0.66 per pound in the Pre-PC period, and it increases to $0.85 per pound in the PC period (or by _____ percent). As indicated by the change in the coefficient of variation, the volatility of this price increases by 40 percent in the PC period, as compared with the Pre-PC period. The monthly average pork farm-to-wholesale margin is 32.5 percent of the wholesale value ("price") of pork in the Pre-PC period, and it increases to 35.1 percent in the PC period (or by ____ percent). As indicated by the change in the coefficient of variation, the volatility of this margin increases by 40 percent in the PC period, as compared with the Pre-PC period.

5.3 Market and Price Analysis: Summary

The empirical evidence indicates that in the PC period the yearly average total quantities of broilers and pork produced in the country increased by approximately 12 percent and 15 percent, respectively. However, an analysis of yearly changes in the quantities of broilers and pork produced indicates that while in the pre-PC period there was a consistent increase in the yearly production of broilers and pork, in the PC period the decreases in the yearly production of broilers and pork in selected years were observed (Tables 3 and 4; Figures 2 and 3). While the implementation of production cuts on average did not decrease the quantities of broilers and pork produced in the PC period, it might have decreased the production's growth rate in both industries. Had the broiler and pork industries not implemented production cuts, the increases in production would have been larger, potentially leading to the oversupply problem, low wholesale prices, and financial losses for broiler and pork processors.

The yearly average product quantity available for domestic consumption per capita increased by 0.7 percent in the broiler industry and decreased by 5.5 percent in the pork industry in the PC period. This is because the export of both types of meat increased, and there was an increase in the U.S. population in this period. While the yearly average export of broilers increased by 35 percent, the yearly average export of pork increased by 105.6 percent. A substantial increase in the export of broilers and pork decreased quantities of these products available for domestic consumption in the PC period.

In the PC period, as compared with the prior period, the volatility of broiler production, export, and quantities available for domestic consumption decreased, the volatility of pork production and export decreased, and the volatility of quantities of pork available for domestic consumption increased. The decreases in the volatility of broiler and pork production may reflect the effects of agricultural supply control practices, leading to more stable agricultural production conditions, which may have had a positive effect on the profitability of broiler and pork processors.

A smaller quantity of product available for domestic consumption would generally increase this product price. The monthly average wholesale prices of broilers and pork increased by 22 percent and 29 percent, respectively, in the PC period, as compared with the prior period. However, these price increases are likely to reflect increases in the costs of feed (corn and soybean meal), which broiler and pork processors passed on to buyers of their products to avoid the oversupply of broilers and pork and low wholesale prices. For example, in the broiler industry, while the feed costs index increased by 67 percent in the PC period, the wholesale price index increased only by 19 percent. The feed costs index increase was about three times the wholesale price index increase. The wholesale price minus feed costs (margin) index in the broiler industry increased only by 4 percent. While the volatility of the wholesale broiler price and margin indices decreased, the volatility of the wholesale pork price and farm-to-wholesale margin increased in the PC period.

6 Antitrust Issues

Beginning in 2016, buyers of broiler chickens, and beginning in 2018, buyers of pork products started filing class action antitrust lawsuits against the largest broiler and pork processors in the country. The buyers alleged that by implementing production cuts and publicly communicating their intentions to implement these production cuts, the processors engaged in unlawful conspiracies with the purpose of fixing, increasing, and stabilizing prices of broiler chickens and pork products paid by various participants in the broiler and pork supply chains (wholesalers, retailers, restaurants, institutional buyers, and final consumers) and violated Section 1 of the Sherman Act (1890). The buyers claimed that they had to pay higher prices for broiler chickens and pork products and were overcharged.

Section 1 of the Sherman Act prohibits contracts, combinations, and conspiracies in restraint of trade in interstate commerce. Price-fixing agreements (cartels or conspiracies) among competitors (firms producing and selling the same or similar products) are examples of the restraints of trade that are most damaging to the market. Price-fixing agreements aim to increase, decrease, or fix (stabilize) product prices, and can be verbal, written, or inferred from the conduct of firms (Federal Trade Commission 2022a). The market effects of a typical output price-fixing cartel are a decrease in the product quantity available in the market, an increase in the product price buyers have to pay, a welfare transfer from buyers to producers (overcharge), and a deadweight loss, due to which there are buyers who do not purchase the product because of higher prices (Figure 4).

In antitrust litigations involving violations of Section 1 of the Sherman Act, plaintiffs must prove the presence of an agreement among competitors violating this section. Direct evidence of this agreement is usually not available, and the agreement must be established using circumstantial evidence.[22] Buyers of broilers and pork products (plaintiffs in the lawsuits) argued that the following conduct of the largest broiler and pork processors constituted the agreements violating section 1 of the Sherman Act.

First, the largest broiler and pork processors publicly communicated their intentions to implement production cuts. Second, the processors shared (exchanged) private, competitor-sensitive information (information related to product quantities, prices, costs, and profit) for the purpose of benchmarking the performance of individual firms.[23] The information exchanges were accomplished by employing a third party, Agri Stats. This firm gathered competitor-sensitive supply and price data from broiler and pork processors, processed these data, and shared the results with the processors.

Private parties (individuals and firms) pursue violations of Section 1 of the Sherman Act by filing civil (private) lawsuits. Direct buyers file private lawsuits under the Clayton Act (a federal law), and they are entitled to recover treble damages (three times the overcharge). Indirect buyers file private lawsuits under the states' antitrust, consumer protection, and unjust enrichment laws and are entitled to recover damages in selected states where these laws exist. The U.S. Department of Justice (DOJ) can file both civil and criminal lawsuits for violations of the Sherman Act. The criminal penalties currently include $100 million for corporations, $1 million for individuals, and up to 10 years in prison for individuals (Federal Trade Commission 2022b).

[22] The circumstantial evidence includes the presence of a parallel conduct of the defendants (for example, parallel pricing) and additional plus factors. Some of the plus factors must support the parallel conduct, and some of the plus factors must indicate the presence of market structures and business practices facilitating collusion. Proving an agreement among competitors violating Section 1 of the Sherman Act represents the main challenge for plaintiffs during antitrust litigations (Baker 1993; Hovenkamp 2005).

[23] Sharing competitor-sensitive information (information on prices, quantities, costs, and customers) may have anticompetitive effects and is likely to raise competition concerns (Bloom 2014). Sharing competitor-sensitive information may be used as a factor when a price-fixing agreement violating Section 1 of the Sherman Act is to be inferred from the firms' conduct.

The class action antitrust lawsuits filed by buyers purchasing broilers and pork directly and indirectly from the largest broiler chicken and pork processors are private (civil) lawsuits. Some of these lawsuits are in the process of being settled. Table 9 summarizes settlements reached by some of the broiler and pork processors with private plaintiffs as of the beginning of 2022.

In June 2019, the DOJ opened its own criminal investigation of price-fixing, bid-rigging, and other anticompetitive conduct in the broiler industry. In June 2020, four executives, and in October 2020, six executives of the largest broiler processors were indicted on price-fixing and bid-rigging charges facing potentially 10 years in prison and up to $1 million in fines (Byington 2021; U.S. Department of Justice 2020a, 2020b). The indicted executives exchanged price information for broiler chickens using text-messages, e-mails, and phone calls.

As a result of the DOJ investigation in the broiler industry, one of the largest broiler processors, Pilgrim's Pride (owned by JBS S.A.), pled guilty and was sentenced to pay a criminal fine of approximately $107 million for participating in a nationwide conspiracy to fix prices and rig bids for broiler chicken products (U.S. Department of Justice 2021).

Table 9. Broiler Chicken and Pork *Private* Antitrust Litigations: Settlements

Date	Defendant	Settlement
Broiler Chicken Antitrust Litigation		
Lawsuit with direct purchasers		
July 2017	Fieldale Farms	$2.25 million
December 2019	Peco Foods	$5.15 million
	George's	$4.25 million
	Amick Farms	$3.95 million
January 2021	Tyson Foods	$80 million
	Pilgrim's Pride (JBS USA)	$75 million
August 2021	Mar-Jac Poultry	$7.975 million
September 2021	Harrison Poultry	$3.3 million
	Direct purchasers: Total	$181.875 million
Lawsuit with indirect purchasers (end-user consumers)		
October 2020–July 2021	*Indirect purchasers: Total* (Fieldale Farms, Peco Foods, George's, Tyson Foods, Pilgrim's Pride, and Mar-Jac Poultry)	$181 million
Total		***$362.875 million***
Pork Antitrust Litigation		
Lawsuit with direct purchasers		
November 2020	JBS USA	$24.5 million
June 2021	Smithfield Foods	$77.3643 million
	Direct purchasers: Total	$101.8643 million
Lawsuit with indirect purchasers		
March 2021	JBS USA	$20 million
Total		***$121.8643 million***

Note: The settlements are as of January 2022. The settlements are from Broiler Chicken Antitrust Litigation webpage (2022), Broiler Chicken Antitrust Litigation (End-User Consumer) webpage (2022), Pork Antitrust Litigation webpage (2022), and Pork Indirect Purchaser Antitrust Litigation webpage (2022).

7 Discussion and Analytical Questions

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

1. Discuss structures of the U.S. broiler and pork industries by focusing on the largest firms and market concentration prior to the implementation of agricultural supply control practices. Highlight changes in market concentration in the recent 15 years.

2. Explain the production system in the U.S. broiler industry. Discuss agricultural supply control practices (production cuts) implemented by the largest broiler processors.

3. Explain the production system in the U.S. hog/pork industry. Discuss agricultural supply control practices (production cuts) implemented by the largest pork processors.

4. Using a graphical analysis, explain conduct and performance of the broiler and pork industries in the following three market situations (note that broilers and pork are “output”).

    4.1. In the first situation, assume that the industries act as classic oligopolies forming output price-fixing cartels. Explain changes in output quantity and output price as the industries shift from an oligopolistic market structure to a monopolistic market structure due to an output price-fixing cartel.

    4.2. In the second situation, assume that the industries act as perfectly competitive industries facing *increasing* marginal costs represented by increasing feed prices. Explain changes in output quantity and output price as the industries respond to a marginal cost increase.

    4.3. In the third situation, assume that the industries act as perfectly competitive industries facing *decreasing* marginal costs represented by decreasing feed prices. Explain changes in output quantity and output price as the industries respond to a marginal cost decrease.

5. Familiarize yourself with the USDA Economic Research Service data sources used to collect data utilized in the empirical analysis presented in the case study (the teaching note provides additional guidance).

6. Perform a basic market and price analysis in the U.S. broiler industry to evaluate changes in the market and price behavior between the two periods of interest: the period of production control practices (PC period) and a prior period (Pre-PC period).

    6.1 Evaluate changes in the averages and coefficients of variation for the U.S. broiler industry production, export, total availability, and availability per capita between the Pre-PC and PC periods by answering the following questions. (6.1.1) Reproduce calculations of changes in the averages and coefficients of variation between the two periods for the economic variables for which answers (the calculated changes) are presented in Table 5. (6.1.2) Calculate changes in the averages and coefficients of variation between the two periods for the economic variables for which answers are not presented in Table 5 and record the calculated changes in this table. (6.1.3) Record relevant percentage changes in the text of the case study (Section 5.1) and describe the results of your analysis.

6.2 Evaluate changes in the averages and coefficients of variation for feed cost index, wholesale price index, and wholesale price minus feed costs (margin) index between the Pre-PC and PC periods by answering the following questions. (6.2.1) Reproduce calculations of changes in the average and coefficient of variation between the two periods for the economic variable for which answers (the calculated changes) are presented in Table 6. (6.2.2) Calculate changes in the averages and coefficients of variation between the two periods for the economic variables for which answers are not presented in Table 6 and record the calculated changes in this table. (6.2.3) Record relevant percentage changes in the text of the case study (Section 5.1) and describe the results of your analysis.

7. Perform a basic market and price analysis in the U.S. pork industry to evaluate changes in the market and price behavior between the two periods of interest: the period of production control practices (PC period) and a prior period (Pre-PC period).

    7.1 Evaluate changes in the averages and coefficients of variation for the U.S. pork industry production, export, total availability, and availability per capita between the Pre-PC and PC periods by answering the following questions. (7.1.1) Reproduce calculations of changes in the averages and coefficients of variation between the two periods for the economic variables for which answers (the calculated changes) are presented in Table 8. (7.1.2) Calculate changes in the averages and coefficients of variation between the two periods for the economic variables for which answers are not presented in Table 8 and record the calculated changes in this table. (7.1.3) Record relevant percentage changes in the text of the case study (Section 5.2) and describe the results of your analysis.

    7.2. Evaluate changes in the averages and coefficients of variation for the wholesale pork price and farm-to-wholesale margin between the Pre-PC and PC periods by answering the following questions. (7.2.1) Reproduce calculations of changes in the average and coefficient of variation between the two periods for the economic variable for which answers (the calculated changes) are presented in Table 7. (7.2.2) Calculate changes in the average and coefficient of variation between the two periods for the economic variable for which answers are not presented in Table 7 and record the calculated changes in this table. (7.2.3) Record relevant percentage changes in the text of the case study (Section 5.2) and describe the results of your analysis.

8. Compare market and price behavior in the broiler and pork industries in the two periods of interest. Are the patterns of changes in quantities and prices similar or different in these two industries between the two analyzed periods? Does the market and price behavior in these industries reflect the effects of agricultural supply control practices discussed in Sections 3.1 and 3.2?

9. Reproduce calculations of broiler price flexibilities reported in Table 3 and use them to perform a price analysis and price forecast in the U.S. broiler industry. Appendix III presents a set of formulas to be used to conduct this price forecast.

   9.1. Use yearly production and price data reported in Table 3 (the data are also provided in the teaching note Excel file) to reproduce calculations of percentage changes in broiler production and price, and broiler price flexibilities reported in Table 3. Compare percentage changes in broiler production and price and the magnitude of price flexibilities in the pre-PC and PC periods. Discuss the results of your analysis.

   9.2. Assume that in the current year, the broiler industry produces 36.5 million pounds of broiler chickens, and broiler chicken price at the wholesale level is $0.71 per pound. The largest broiler processors plan to implement production cuts by decreasing broiler production by 4 percent in the next year. Assume that the broiler price flexibility is -2. Calculate (predict) broiler chicken price at the wholesale level in the next year by using a set of formulas presented in Appendix III. Show on a graph a demand curve and broiler price-quantity combinations corresponding to the two analyzed years (current year and next year). Describe the results of your analysis.

   9.3. Assume that in the current year, the broiler industry produces 39.6 million pounds of broiler chickens, and broiler chicken price at the wholesale level is $0.77 per pound. The buyers of broiler chickens filed antitrust lawsuits alleging that by implementing production control practices the largest broiler processors engaged in a price-fixing conspiracy. In the next year, the largest broiler processors will not implement any production cuts. The broiler production is expected to increase by 5 percent, because meat yield per chicken (chicken weight) has been increasing due to improvements in broiler genetics and feed efficiency. Assume that the broiler price flexibility is -3. Predict broiler chicken price at the wholesale level in the next year by using a set of formulas presented in Appendix III. Show on a graph a demand curve and broiler price-quantity combinations corresponding to the two analyzed years (current year and next year). Describe the results of your analysis.

10. Reproduce calculations of pork price flexibilities reported in Table 4 and use them to perform a price analysis and price forecast in the U.S. pork industry. Appendix III presents a set of formulas to be used to conduct this price forecast.

    10.1. Use yearly production and price data reported in Table 4 (the data are also provided in the teaching note Excel file) to reproduce calculations of percentage changes in pork production and price, and pork price flexibilities reported in Table 4. Compare percentage changes in pork production and price and the magnitude of price flexibilities in the pre-PC and PC periods. Discuss the results of your analysis.

    10.2. Assume that in the current year, the pork industry produces 23 million pounds of pork, and the pork price at the wholesale level is $0.58 per pound. The largest pork processors plan to implement production cuts by decreasing pork production by 2.5 percent in the next year. Assume that the pork price flexibility is -16. Calculate (predict) pork price at the wholesale level in the next year by using a set of formulas presented in Appendix III. Show on a graph a demand curve and pork price-quantity combinations corresponding to the two analyzed years (current year and next year). Describe the results of your analysis.

10.3. Assume that in the current year, the pork industry produces 25.6 million pounds of pork, and the pork price at the wholesale level is $0.84 per pound. The buyers of pork filed antitrust lawsuits alleging that by implementing production control practices the largest pork processors engaged in a price-fixing conspiracy. In the next year, the largest pork processors will not implement any production cuts. The pork production is expected to increase by 5 percent, because meat yield per hog (hog weight) used to produce pork has been increasing due to improvements in hog genetics and feed efficiency. Assume that the pork price flexibility is -4. Predict pork price at the wholesale level in the next year by using a set of formulas presented in Appendix III. Show on a graph a demand curve and pork price-quantity combinations corresponding to the two analyzed years (current year and next year). Describe the results of your analysis.

11. Explain the reasons that buyers of broiler chickens and pork filed antitrust lawsuits against the largest broiler and pork processors in the United States. Discuss the role of Section 1 of the Sherman Act in regulating the conduct of broiler and pork processors in the analyzed industry situation. Explain the recent outcomes of the antitrust lawsuits filed by the buyers of broiler chickens and pork against the largest processors.

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Appendix I. U.S. Broiler and Pork Industries: Nominal and Real Price Analysis

Nominal wholesale prices are used in the empirical analysis presented in the case study for the following reasons.

(1). Figure 4 demonstrates changes in output quantity and output price due to the exercise of seller market power of meat processors. To understand the effect of a reduction in the output quantity on the output price—the output price increase or the overcharge—the output price has to be assumed to be an actual market price (nominal price). If a real price (the price adjusted for inflation) is used, theoretically there may be a price decrease or no price increase depending on the adjustments made to the price series. Figure 4 explains the industry's conduct and performance in the short-run period. For the empirical analysis to be consistent with this figure, nominal wholesale prices are used.

(2). When meat processing companies make decisions on output quantities to produce, they consider actual market prices that they currently observe. For example, when broiler and pork processors made public statements on their plans to implement production cuts, they made these production decisions based on current market prices (see several excerpts from the complaints presenting these statements included in Section 3 of the case study). Similarly, agricultural producers in general make their production decisions by taking into consideration current market prices (see a discussion of a general agricultural production and price cycle and a discussion of a hog supply and price cycle included in Section 3 of the case study).

(3). The empirical analysis presented in this case study is a very simplified version of the analysis that would be used in antitrust proceedings to calculate damages: the overcharge rectangle in Figure 4. When the overcharge (the output price increase due to illegal collusion) is calculated, actual firm-specific transaction prices are used. These prices are not adjusted for inflation, because this adjustment may distort the size of damages and may lead to lower damages or no damages.

(4). Some of the U.S. Department of Agriculture Economic Research Service reports, which compare yearly production and price data for agricultural commodities over several years use actual market prices (Dohlman and Livezey 2005; Dohlman, Foreman, and Da Pra 2009).

Table A1 presents descriptive statistics for nominal and real wholesale prices of broiler chickens like the one reported in Table 7. To adjust nominal prices for inflation two indices are used. The first one is the Producer Price Index (PPI) reported by the U.S. Bureau of Labor Statistics (BLS) for the aggregate group "meats, poultry, and fish" (U.S. Bureau of Labor Statistics 2022a). The second one is the Wholesale Price Index (WPI) for broilers reported by the U.S. Department of Agriculture Economic Research Service (2022b).[24] The changes in the monthly average real prices between the pre-PC and PC periods depend on the index used to adjust nominal prices.

The monthly average real wholesale price calculated using PPI decreases from 48.13 cents per pound in the pre-PC period to 45.49 cents per pound in the PC period, which is a decrease by 2.64 cents per pound or 5.5 percent. The monthly average real price calculated using WPI increases from 56.57 cents per pound in the pre-PC period to 57.11 cents per pound in the PC period, which is an increase by 0.53 cents per pound or 0.9 percent. This price increase is much smaller in magnitude than the monthly

[24] While the BLS PPIs for "poultry" and "chicken" groups are available, their values are missing for all months of 2009, therefore they are not used in the analysis.

average nominal price increase: 14.43 cents per pound or 22.5 percent. The teaching note Excel file includes data and calculations.

Table A1. The U.S. Broiler Chicken Monthly Wholesale Nominal and Real Prices, 2000—2015

Average/Coefficient of Variation (CV)	Nominal Wholesale Broiler Price	Producer Price Index (PPI) for Meats	Wholesale Price Index (WPI) for Broilers	Real Wholesale Broiler Price Adjusted Using	
				PPI Meats	WPI Broilers
	Cents per pound	1982 = 100	1998–2000 = 100	Cents per pound	
Pre-Production Control Period (Pre-PC Period): 2000–2007					
Average	64.26	133.24	113.47	48.13	56.57
CV	0.16	0.08	0.15	0.12	0.03
Production Control Period (PC Period): 2008–2015					
Average	78.69	174.21	137.77	45.49	57.11
CV	0.11	0.12	0.11	0.10	0.01
Change: PC Period, Relative to Pre-PC Period					
Average	14.43	40.97	24.30	-2.64	0.53
Average (percentage change)	22.5	30.7	21.4	-5.5	0.9
CV	-0.05	0.04	-0.04	-0.01	-0.03
CV (percentage change)	-32.3	56.1	-29.0	-12.3	-76.1

Data source for nominal prices: USDA Economic Research Service (2022b).
Note: “PPI meats” is Producer Price Index (by commodity) for processed foods and feeds: meats, poultry, and fish; monthly, seasonally adjusted; Series ID WPS022 (U.S. Bureau of Labor Statistics 2022a). “WPI broilers” is composite wholesale price index for broilers; monthly (U.S. Department of Agriculture Economic Research Service 2022b). Real price = (Nominal price/Index) * 100.

Table A2 presents descriptive statistics for nominal and real wholesale prices of pork like the one reported in Table 7. To adjust nominal prices for inflation two indices are used. The first one is the Producer Price Index (PPI) reported by the BLS for the aggregate group “meats, poultry, and fish” (U.S. Bureau of Labor Statistics 2022a). The second one is the PPI reported by the BLS for a less aggregated group “pork products” (U.S. Bureau of Labor Statistics 2022b). The changes in the monthly average real prices between the pre-PC and PC periods depend on the index used to adjust nominal prices.

The monthly average real wholesale price calculated using PPI for meats decreases from 48.60 cents per pound in the pre-PC period to 47.12 cents per pound in the PC period, which is a decrease by 1.48 cents per pound or 3 percent. The monthly average real price calculated using PPI for pork increases from 52.96 cents per pound in the pre-PC period to 55.80 cents per pound in the PC period, which is an increase by 2.84 cents per pound or 5.4 percent. This price increase is much smaller in magnitude than the monthly average nominal price increase: 18.86 cents per pound or 28.7 percent. The teaching note Excel file includes data and calculations.

Table A2. The U.S. Pork Monthly Wholesale Nominal and Real Prices, 2000—2017

Average/Coefficient of Variation (CV)	Nominal Wholesale Pork Price	PPI for Meats	PPI for Pork	Real Wholesale Pork Price Adjusted Using	
				PPI Meats	PPI Pork
	Cents per pound	1982 = 100		Cents per pound	
Pre-Production Control Period (Pre-PC Period) : 2000–2008					
Average	65.67	135.24	123.85	48.60	52.96
CV	0.13	0.08	0.08	0.11	0.09
Production Control Period (PC Period): 2009–2017					
Average	84.53	179.15	150.86	47.12	55.80
CV	0.18	0.10	0.13	0.14	0.09
Change: PC Period, Relative to Pre-PC Period					
Average	18.86	43.91	27.01	-1.48	2.84
Average (percentage change)	28.7	32.5	21.8	-3.0	5.4
CV	0.05	0.02	0.05	0.03	0.00
CV (percentage change)	40.2	21.8	60.7	32.2	-1.2

Data source for nominal prices: USDA Economic Research Service (2022b).
Note: “PPI meats” is PPI (by commodity) for processed foods and feeds: meats, poultry, and fish; monthly, seasonally adjusted; Series ID WPS022 (U.S. Bureau of Labor Statistics 2022a). “PPI pork” is PPI (by commodity) for processed foods and feeds: pork products, fresh, frozen, or processed, except sausage; monthly, seasonally adjusted; Series ID WPS022104 (U.S. Bureau of Labor Statistics 2022b). Real price = (Nominal price/Index)*100.

Appendix II. Price Flexibilities

Price flexibilities are elasticities associated with price-dependent (inverse) demand functions, according to which changes in product quantities affect changes in product prices (Hudson 2007). The price flexibility is the inverse of the own-price elasticity of demand associated with a quantity-dependent demand function (Houck 1965). Price-dependent demand functions generally reflect the nature of agricultural production and price cycles, according to which the total quantity of agricultural products produced during production seasons affects market prices for these products during marketing seasons (Moore 1919; Houck 1965; Bolotova 2017, 2019).

Price flexibility indicates a percentage increase (decrease) in product price, which follows a 1-percent decrease (increase) in product quantity demanded. Theoretically, price flexibilities are expected to be negative. There are two approaches to calculate price flexibilities.

The first approach is to use formula [1]. This approach is used when a price-dependent demand function (equation) is not available, but product prices and quantities for two consecutive years are available (Q1 and P1 are the price-quantity combination for the first year, and Q2 and P2 are the price-quantity combination for the following year). This approach is used in this case study.

$$Price\ Flexibility = \frac{\%\,\Delta\ in\ P}{\%\,\Delta\ in\ Q}, \tag{1}$$

where $\%\,\Delta\ in\ P = [\Delta\ in\ P/P1] \times 100\% = [(P2 - P1)/P1] \times 100\%$, $\%\,\Delta\ in\ Q = [\Delta\ in\ Q/Q1] \times 100\% = [(Q2 - Q1)/Q1] \times 100\%$, and Δ indicates "change."

The second approach is to use formula [2]. This approach is suitable when a price-dependent demand function (equation) is available. Price-dependent demand function: $P = a - b \times Q$, where P is product price measured in $ per unit, and Q is product quantity measured in physical units.

$$Price\ Flexibility = -b \times \frac{Q}{P}, \tag{2}$$

where -*b* is the derivative of price with respect to quantity. Q and P in the above formula are associated with a particular point of interest or the average values. Note that formula [2] is a rearranged version of formula [1].

$$Price\ Flexibility = \frac{\%\,\Delta\ in\ P}{\%\,\Delta\ in\ Q} = \frac{\Delta\ in\ P}{P1} \times 100\% \Big/ \frac{\Delta\ in\ Q}{Q1} \times 100\% = \frac{\Delta\ in\ P}{\Delta\ in\ Q} \times \frac{Q1}{P1} = -b \times \frac{Q1}{P1}$$

Appendix III. A Methodology of Output Price Forecast Using Price Flexibility

Table A3. Output Price Forecast: Data and Formulas

Step		Notation	Value or Formula
	Current Year		
	Quantity (million pounds)	*Q1*	Value is provided
	Price ($ per pound)	*P1*	Value is provided
	% change in Quantity	*% change in Q*	Value is provided
	Price flexibility		Value is provided
	Next Year		***Calculate Using Formulas***
1	Change in Quantity (million pounds)	*change in Q*	$= \frac{Q1 * \%\ change\ in\ Q}{100}$
2	Quantity (million pounds)	*Q2*	$= Q1 + change\ in\ Q$
3	% change in Price	*% change in P*	$= Price\ Flexibility * \%\ change\ in\ Q$
4	Change in Price ($ per pound)	*change in P*	$= \frac{P1 * \%\ change\ in\ P}{100}$
5	Price ($ per pound)	*P2*	$= P1 + change\ in\ P$

Note: The objective of a price forecast is to predict the product price in the next year (P2). The teaching note Excel file provides all formulas and answers to Questions 9 and 10.

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Case Study

Economic Dynamics in the Beef Food Supply Chain under Pandemic Conditions

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Abstract: This case study discusses the potential effects of COVID-19 pandemic on the U.S. beef market during the first half of 2020. This sector confronted significant economic distortions caused by the increasing rate of infection in meat processing and packaging plants. We illustrate the COVID-19 related effects on the beef industry by using cattle-meat marketing channel framework, which comprises of two markets: cattle raw meat cuts supplied by farmers, and retailed processed meat sold by retailers and wholesale markets to final consumers as packed and processed products. The case study discusses different supply and demand shocks affecting the meat market system during and after the lockdown period. The article also explores the potential changes in equilibrium prices in alternative meat markets and how these could affect prices in conventional meat products. The teaching note discusses the objectives and provides further recommendations on the delivery of the case study, including a team peer evaluation.

1 The U.S. Beef Market During the COVID-19 Pandemic

As of May 2020, the meat industry faced significant economic distortions caused by the COVID-19 pandemic. From the demand side, demand declined as major clients, such as restaurants and schools, ceased operations during the lockdown (Peña-Lévano, Burney, and Adams 2020a; Cowles 2020; Reuters 2020). In addition, household beef demand in 2020 was expected to decline due to the perception of an imminent recession (Corkery and Yaffe-Bellany 2020). This is partly because income-constrained consumers usually shift away from ruminant meat products during recessions in favor of cheaper commodities such as chicken, turkey, or plant-based proteins (Plumer 2020). From the supply side, large processing plants closed operations as workers' COVID-19 infection numbers rose. Farmers were unable to sell their animals, which forced farmers to hold them for a longer period than originally scheduled (Plumer 2020).

2 Learning Objectives

This case study discusses the potential effects of the COVID-19 pandemic on the U.S. beef market during the first half of 2020, using a marketing model structure developed by Norwood and Lusk (2018), which shows graphically the effects of the pandemic on both U.S. production and demand, making it suitable for upper undergraduate and graduate courses in agricultural marketing and price analysis.

The case study intends to offer students a real-world application through collaborative group discussions, which have been shown to improve students' analytical abilities (Kiesel et al. 2020). Experiential learning through case studies also helps to sharpen metacognitive skills such as their ability to organize and process information (Melo et al. 2021). Likewise, in order to enrich the students' learning experience, it is recommended to use online tools, such as discussion boards, to provide a personalized assessment (Peña-Lévano 2020) and motivate instructor-student interactions (Peña-Lévano and Melo 2022).

The specific learning objectives (LO) of this case study are:

LO1. Graphically represent the equilibrium in the U.S. beef market without distortions. Understand how the cattle-meat marketing channel can be affected by changes in macroeconomic conditions.

LO2. Determine the equilibrium price and quantity of each market in the multisector models based on market information provided.

LO3. Forecast the direction of change for equilibrium prices and quantities due to economic distortions induced by the pandemic in a marketing channel model.

3 The Cattle-Meat Marketing Model

The beef industry can be modeled graphically through the ***cattle-meat marketing channel framework***, developed by Norwood and Lusk (2018). This structure illustrates the supply and demand of two related markets (i.e., intermediate and final product) within the same industry. In this case, these two products are: (1) ***Cattle raw meat cuts*—**supplied by farmers, processed at slaughterhouses, and sold to restaurants, schools, and grocery stores. The raw ***meat*** supply is represented by the line $\boldsymbol{S^M}$, and derived demand is $\boldsymbol{DD^0}$. (2) ***Retail processed meat*—**sold by retailers and wholesale markets to final consumers as packed and processed products. The ***retail*** meat supply is displayed by line $\boldsymbol{S^R}$, with its respective demand $\boldsymbol{D^0}$. The marketing-channel framework assumes ***fixed proportions technologies***: the proportion of cattle raw meat used in processed meat is constant in the short term. In other words, the retail meat supplied $\boldsymbol{Q}$ is a fixed fraction $\boldsymbol{k}$ of the farm raw meat $\boldsymbol{Q_M}$ (i.e., $Q = kQ_M$). These markets are represented in Figure 1, with pre-coronavirus equilibrium price $\boldsymbol{P^{M^0}}$ for the raw ***meat*** market and equilibrium retail meat price $\boldsymbol{P^{R^0}}$ with equilibrium quantity $\boldsymbol{Q}$ of meat in the market.

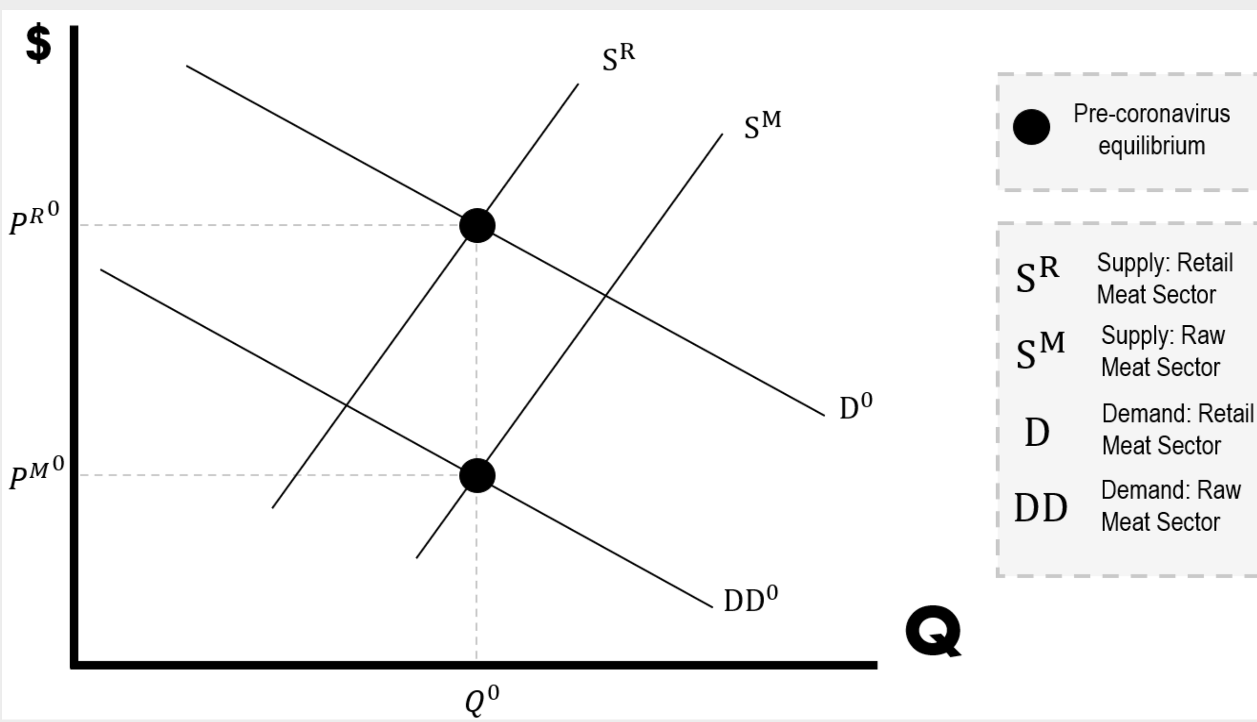

Figure 1. Baseline of the Cattle-Meat Marketing Channel

4 Disturbances in the Meat Market Channel

COVID-19 pandemic has two distinctive periods, delineated by the stay-at-home mandate:

- ***Period 1*:** Stay-at-home orders are imposed in mid-March 2020, with **high infection rates** in most states. This period ended in mid-May 2020 with partial opening of operations.

- ***Period 2*:** Occurring after mid-May 2020—end of the first pandemic wave. Lockdown **restrictions** are being **relaxed** in most states in the U.S., with **infection curve flattening** (and/or decreasing in June depending on the state). Considering the information from this case study is based on news from June 2020 (just months after the reopening), Period 2 is a *predictive situation*. This case is later updated with subsequent information learned in May 2021, discussed in Section 6 (Questions).

4.1 Market Predictions During Stay-at-Home Orders in Period 1

The pandemic's first stage is characterized by an increasing infection rate and stay-at-home orders in most states. The beef industry suffered changes in dynamics, driving an overall decrease in output (**from Q^0 to Q^1**) due to the following reasons (represented orderly in Figure 2):

(1) ***Retail meat supply*** **decreased** due to disruptions in slaughterhouse and large processing plant operations after many workers contracted the virus (Plumer 2020) and raised the processing cost of consumer-ready meat products (Ledbetter 2021). In addition, labor shortages persisted despite cash incentives from companies to lure workers back to work (Peña-Lévano et al. 2020b; Restuccia and Bunge 2020). As a result, beef production for the last week of April 2020 was 25 percent lower compared to the same week in the previous year (Restuccia and Bunge 2020).

(2) Farmers and ranchers were unable to sell their animals because slaughterhouses, restaurants, and schools were temporarily closed, leading to **slumping demand for *raw meat*** (Plumer 2020). Only few restaurants were open under pick-up or delivery options. Rabobank estimated about a 30 percent fall in U.S. meat demand during March 2020 (Reuters 2020). Holding livestock inventory for a period longer than planned increased feeding and maintenance costs. Millions of pounds of frozen beef were stored waiting to be sold in the market (Plumer 2020), creating an oversupply that **pushed down *raw meat* prices** (Ledbetter 2021), graphically, $P^{M^0} \rightarrow P^{M^1}$.

(3) However, there was a **spike in *retail*** packed and processed meat sales as (i) home cooking and takeout or drive-through sales increased (Searcey 2020), (ii) consumers anticipated an imminent meat shortage, motivating panicked buying of products (Corkery and Yaffe-Bellany 2020), and (iii) a fraction of COVID-19 relief payments were used to buy staple groceries (Skidmore 2020). This spike in meat consumption, along with disruptions in meat-packing plants, induced ***retail meat* prices to rise** (Ledbetter 2021), **from P^{R^0} to P^{R^1}.** This increase in retail price with the decrease in raw meat price induced an increase in the margin (i.e., the price difference between final consumer price P^{R^1} and farm price P^{M^1}), displayed in Figure 2.

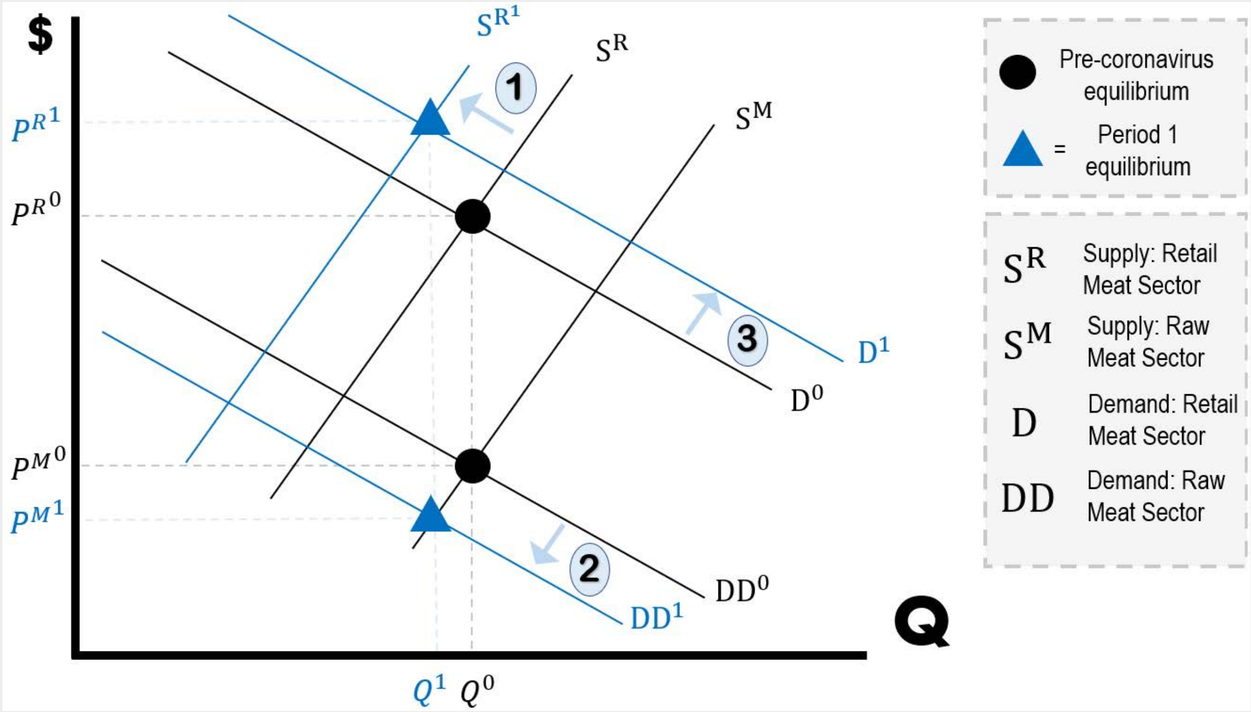

Figure 2. Dynamic Changes During *Period 1* in the Cattle-Meat Marketing Channel

4.2 Market Predictions for Situation after May 2020: Predictive Situation in Period 2

Many states gradually reopened activities in May 2020 as the peak of the infection curve seemed to have passed (Mervosh et al. 2020). However, the lockdown triggered a recession, as many companies shut down operations leaving more than thirty million Americans unemployed and mostly dependent on unemployment benefits (Chaney and King 2020). As a result, the U.S. economy shrank by 4.8 percent in the first quarter of 2020, and the looming recession was expected to be worse than the Great Recession of 2008 (Crutsinger 2020). This information allows to make short-term **predictions** regarding the meat market situation after reopening operations. Thus, Period 2 forecasts a fall in beef output (from $\boldsymbol{Q^1}$ to $\boldsymbol{Q^2}$) as a post-effect of the stay-at-home mandate, given the following considerations (represented orderly in Figure 3):

(1) Restaurants were required to resume operations partially (Mervosh et al. 2020). Processing plants were encouraged to continue production under the Defense Production Act. Nonetheless, the infection rates among workers remained high (Restuccia and Bunge 2020). A second wave of infection could intensify labor shortages, causing a negative production shock (i.e., **left-upward shift of *retail meat* supply**). Meat shortages might worsen as consumers continue buying beef products, and meat inventories could be exhausted (Groves 2020; Johansson 2020).

(2) As trends from the 2008 financial crisis, households tend to purchase less red meat and shift toward a more diversified protein diet under declining disposable incomes (Yang, Raper, and Pruitt 2019). Moreover, polls indicate that consumers tend to eat less meat in post-recession periods (Gabbett 2017). The long-term exposure to the pandemic event might stimulate meat safety fears, shifting away from overconsumption of animal protein (McFadden et al. 2020). Thus, ***retail meat* demand** is expected to **fall** in *Period 2*, possibly lower than the initial equilibrium quantity price (pre-coronavirus era).

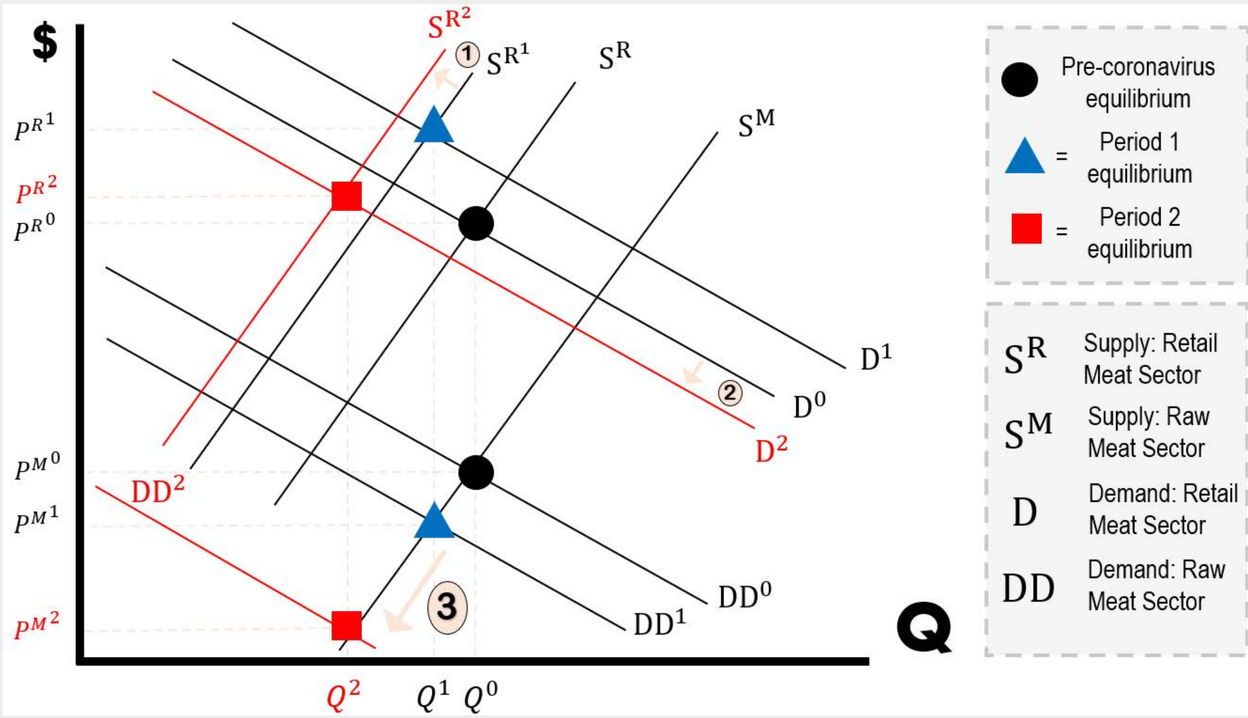

Figure 3. Dynamic Changes During *Period 2* in the Cattle-Meat Marketing Channel

(3) The decline in meat demand and labor shortages in processing plants, mainly due to concerns about health conditions in meat plants (Irwin 2021), could shift **cattle *raw meat* demand downward**. Given the rise of alternative meat product supply by both plant-based and meat-based companies following the pandemic, it might be possible for consumers to meet their demand for protein foods by also consuming meat alternatives (Plumer 2020; Yaffe-Bellany 2019). Lower farm cattle demand will likely **depress the price of cattle** ($P^{M^1} \rightarrow P^{M^2}$), and the lower meat supply will **ergo impact meat price** ($P^{R^1} \rightarrow P^{R^2}$; Pitt 2020).

5 Summary of the Situation in the Case Study

The pandemic's lockdown restrictions put pressure on the meat industry in many forms: (1) labor shortages lead to closing of and reduced plant operations, (2) diminished demand from traditional clients (restaurants and schools) that closed or are operating at partial capacity, and (3) farmers suffering economic losses as animal inventory holding periods are longer than expected, increasing production costs, and reducing revenue generation potential. All these led to a decrease in cattle raw cut prices and an increase in meat prices at the beginning of the pandemic.

Over time, uncertainty in the effective containment of the pandemic or prognoses of permanently improving meat-processing employee safety measures may maintain higher consumer meat prices. At the same time, consumers may shift their diet toward alternative protein sources perceived to be healthier and safer than conventional animal proteins. These potential changes would likely influence other markets. Consequently, potential changes in equilibrium prices in alternative meat markets would affect future equilibrium prices of conventional meat products.

6 Discussion Questions

(1) In the case study, shifts in supply and/or demand on agricultural markets for ***Period 2*** were predicted based on events during the first quarter of 2020 (as of May 2020). The pandemic and economic conditions, however, have changed since then, with important implications for the cattle-meat marketing channel. Therefore, let us now consider additional information about events during the last three quarters of 2020. Below is some information (as of May 2021) that you will need in order to answer the questions provided next:

While the contracting U.S. economy was expected to reduce disposable income and cause consumers to buy less meat, instead real disposable income increased significantly because of various government stimulus programs (Federal Reserve Economic Data 2021). At the same time, meat-packing plants resumed operations after incurring additional costs to improve employee safety measures (Dixon and Rimmer 2021). As a result, in 2020, consumer prices for meat and other animal products slightly declined between June and November, while farm-level prices for animal products increased between April and November (Ledbetter 2021). While conditions are not back to their pre-coronavirus trends in the meat industry, they seem to have improved since the beginning of the lockdowns.

Based on the above information and any additional information you may investigate (optional), answer the following questions:

(1.1) Use a graph to illustrate the pandemic-induced shocks on the marketing channel for cattle raw meat and processed meat for an updated version of *Period 2*, that is, market predictions (in May 2021) for *Period 2*. What **changes in prices** would you predict to occur in *Period 2*?

(1.2) Can a complete release of lockdown restrictions and the end of the COVID-19 pandemic bring **prices back to the original trend**? Why or why not?
As shown in Figure 2, a reduction in beef production during *Period 1* raised the price of beef products. As a result, consumers may have substituted beef meat for other protein sources (Yaffe-Bellany 2019). In this problem, consider veggie burgers as a direct competitor to the meat industry. This vegetarian/vegan market has two products: peas grown on farms and veggie patties (made of peas). Assume that subsequent to *Period 1*, there was an increase in the demand for plant-based meat products and no short-term response in their respective supply.
Explain the effect of the COVID-19 pandemic on the veggie burger market using the two-sector marketing channel framework.

(2) Up to now, we have assumed that a shift in supply and/or demand in one market does not affect other market systems (i.e., by using partial equilibrium analysis). We will now relax this assumption and assume that economic shocks in the cattle-meat marketing channel do affect related markets. Use the information below regarding related markets and ***Table 1*** to answer the upcoming questions:

Table 1. Demand Elasticities for Beef and Plant-Based Alternatives During COVID-19

Elasticity Type	Elasticity Value
Own-price elasticity of demand for plant-based patties	-0.03
Own price elasticity of demand for beef	-0.08
Cross-price elasticity of demand for ground beef with respect to the price of plant-based patties (veggie burgers)	0.08
Cross-price elasticity of demand for pork with respect to the price of beef	0.24
Cross-price elasticity of demand for beef with respect to the price of pork	0.28

Source: Tonsor, Lusk, and Tonsor (2021); Lusk (2021)

> *U.S. sales of plant-based meat alternatives have increased, up by almost 200 percent in April 2020 compared to the same month in 2019. This contrasts with jumps of 30 percent over the same period for fresh meat (Terazano and Meyer 2020). Different factors explain this large increase in sales of meat substitutes such as meat supply shortage, amplified concern about food safety and health (McFadden et al. 2020), and advertisement of meat alternatives seeking to attract new consumers (Nierenberg 2020). Nevertheless, COVID-19 just added momentum to an already rapidly growing trend toward reduced animal-based food consumption (Haberman 2020).*

(3.1) Draw the marketing channel for cattle raw meats and processed meat products in graph (*a*). Using a separate graph (*b*) (preferably draw these side by side), represent the food marketing channel of a meat substitute with two systems (retail and farm production). Draw the graphs for parts (*a*) and (*b*), and depict the differences in elasticities of supply and demand for each of the primary markets (e.g., beef).

(3.2) Assume that the supplies of beef and plant-based meat were equally affected by the pandemic in *Period 1* (e.g., both supplies shift to the left by the same proportion due to labor shortages). Based on the graphs in Question (**3.1**), explain how the markets were affected and whether there is a more significant impact on the price in one market compared to the other.

(3.3) Now suppose that there was a decrease in the **retail beef** supply, no change in the **supply of plant-based** meat, and upward pressure on the plant-based meat price due to gradual **increases in demand** for **animal meat alternatives**. Based on the graphs you produced for Question (**3.1**) and your knowledge on market equilibrium, illustrate in three separate graphs: (*a*) *Period 1*: the shift in the retail supply curve and derived demand for raw meat cuts in the cattle-meat marketing channel, (*b*) *Period 1*: how a higher beef price influences plant-based meat price in the marketing channel of meat substitutes, and (*c*) *Period 2*: the **feedback effect** from the new plant-based meat price on the beef price in the cattle-meat marketing channel.

(3.4) Use the conclusions from Question (**3.3**) and elasticities from **Table 1** to refute the following statement: "*an increase in the supply of pork chops following the pandemic recovery is unlikely to affect the equilibrium price and quantity of the steak market*."

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Teaching and Educational Commentary

The Empathetic Course Design Perspective

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Abstract
Empathy, the ability and willingness to take the cognitive and emotional perspective of others, is becoming increasingly important within academia. We introduce our Empathetic Course Design Perspective that refers to the intentional infusion of empathy into a course. We discuss the overarching beliefs that underlie this perspective, such as instructors' commitment to inclusive teaching practices. In this commentary, we present practical recommendations for incorporating this perspective into your classes, in terms of course syllabi; schedules and routines; modalities; policies; and assignments and assessments. We believe this template is flexible and can be applied to any course (e.g., lower- and upper-level classes), in any modality (e.g., face-to-face, hybrid/hyflex, online), and in any academic discipline. Ultimately, we believe the Empathetic Course Design Perspective can transform our courses into learning spaces that are more positive, supportive, and engaging for us as instructors and, more importantly, for our students.

1 Introduction

There are many stressors in the world today (e.g., COVID-19, structural racism, gun violence, social/civil unrest), including within academia specifically. For instance, academia has historically struggled with inclusivity (e.g., "ivory tower"; Kapareliotis and Miliopoulou 2019; Bourabain 2021), and issues related to diversity, equity, inclusion, and belonging (DEIB) have been considered a growing challenge in disciplines such as agricultural economics education in recent years (e.g., Lambert Snodgrass et al. 2018; Wiersma-Mosley 2019). Additionally, the COVID-19 pandemic created many challenges for teaching and learning broadly (e.g., rapid transitions to remote/online modalities; Johnson, Veletsianos, and Seaman 2020; Silva de Souza et al. 2020; Sunasee 2020) that have inspired changes to pedagogy (e.g., Sá and Serpa 2020). College classes and instructors should not add to these global and academic stressors, but should rather create a climate in which students are supported in their learning. As a result, we believe there is a growing need for more intentional and explicit demonstrations of empathy within academia, specifically in the classes we teach. Thus, we propose our Empathetic Course Design Perspective and provide practical, thoughtful recommendations for college instructors to make their classes more inclusive and equitable learning spaces based on this framework.

2 Our Empathetic Course Design Perspective

The Empathetic Course Design Perspective refers to the intentional infusion of empathy into one's course structure, goals, policies, and interactions with students.[1] Empathy is the ability and willingness to take the cognitive and emotional perspective of others (e.g., Elliott et al. 2011). Our Empathetic Course Design Perspective puts empathy at the forefront of all course decision-making, because we believe proactively and intentionally considering the cognitive and emotional perspectives of students promotes the collective experiences of both students and instructors in their classes (see also Franzese 2016). We

[1] See the "Empathetic Course Design Perspective" *Engage the Sage* video.

believe this approach transforms courses into learning spaces that are more positive, supportive, and engaging for both instructors and students, ultimately promoting better learning for students.

1.1. Underlying Beliefs of the Empathetic Course Design Perspective

The Empathetic Course Design Perspective reflects an instructor's commitment to a set of overarching teaching beliefs and behaviors. First and foremost, the core of our Empathetic Course Design Perspective is the belief that classes begin with instructors. Consistent with this idea, we explicitly promote the concept of "trickle down engagement" (TDE; Saucier 2019b; Saucier, Miller et al. 2022).[2] According to TDE, instructors' experiences with, and engagement in, their own courses start the learning process. In other words, when instructors are more engaged in and excited about their course content, their students are consequently more engaged in and excited about learning which, in turn, helps students to more successfully learn the content (Saucier, Miller et al. 2022). Extending TDE, the personas and perspectives of the instructors provide the foundations for teaching and learning (e.g., Zagallo et al. 2019) by dictating the teaching philosophies and practices that help provide structure for the various components of a given course as well as guide students' learning (Baran, Correia, and Thompson 2013). Specifically, we recommend instructors adapt their teaching personas, philosophies, and practices to bring *Preparation*, *Expertise*, *Authenticity*, *Caring*, and *Engagement* (PEACE; Saucier 2019a; Saucier and Jones 2020) to their classes (see Table 1). Although instructor preparation (Gullason 2009) and expertise (Korte, Lavin, and Davies 2013) are important for business and economics classes and necessary for teaching excellence, they alone are not sufficient for creating a positive classroom environment. That is, to create a classroom environment that facilitates the success of *all* students, we believe instructors should be authentic (i.e., a

Table 1. Descriptions and Examples of PEACE Components

Component	Description	Examples
1. Preparation	Having a plan for what (and how) you will teach	Creating and sharing lesson plans, reviewing content prior to lecture, anticipating students' questions, mental preparation, logistical preparedness
2. Expertise	Having content knowledge and understanding on how you will convey this knowledge to students in an accessible way	Demonstrating your content mastery, providing real-life and relatable examples of course concepts, anticipating confusing topics, thinking out loud
3. Authenticity	Demonstrating a genuine representation of yourself and your personality to your students	Visiting with students before class, sharing your successes and failures with students, referencing personal experiences with content matter
4. Caring	Demonstrating your commitment to your students' academic and personal success	Empathizing with students' circumstances, thanking students, intentionally inviting students to ask questions, checking in with students who may be in distress
5. Engagement	Having complete investment (at cognitive, emotional, and behavioral levels) in your course-related duties	Demonstrating your interest in the material, using verbal cues (e.g., "This is super interesting"), showing that you enjoy teaching

[2] See our "Welcome to Engage the Sage" video.

genuine representation of the instructor and their personality), demonstrate caring toward their students (i.e., showing commitment to students' academic and personal success), and display engagement with course content (i.e., complete investment in course-related duties at cognitive, emotional, and behavioral levels). In creating a classroom that achieves more than merely "information sharing," students ultimately learn better. Teaching philosophies are (or should be) intentional, purposeful, and dynamic in their explicit connection to the course structure and content. However, teaching personas and practices should also be flexible and allow for adaptation to changing circumstances.

Second, instructors value and care for themselves and their students, understand that subjective experiences matter, believe that empathy is more important than rigor, agree that flexibility supports teaching and learning, and provide guidance and grace to themselves and their students when needed. Third, instructors agree to inclusively promote student learning, remove barriers to their students' educations (e.g., use plain language principles), consider the contexts in which their students learn and in which they teach, infuse their classes with consistency and predictability to reduce students' anxiety (e.g., predictable routines within the course structure), make their expectations clear and reasonable for both their students and themselves, and justify and explicitly communicate the reasons for their teaching practices. Given that women and minorities have been historically underrepresented in agricultural economics textbooks (e.g., Feiner and Morgan 1987), faculty (e.g., McCluskey 2019), and the field itself (e.g., Bayer and Rouse 2016), we believe it is especially important for instructors in these classes to infuse empathy and inclusivity into their teaching to optimize the experience of students from *all* backgrounds. Finally, they commit to seek and use feedback from their students and to provide fair and reasonable ways for their students to demonstrate their learning.

Overall, an instructor's commitment to these overarching beliefs both demonstrates and facilitates the support and success of all their students. The adoption of these beliefs will also benefit instructors, not just students, by creating more fulfilling and successful experiences in teaching and learning. While we discuss these beliefs in relation to agricultural economics and business classes, they are important for instructors of all courses to demonstrate. To aid in this process, we present practical recommendations for how to incorporate the Empathetic Course Design Perspective into your classes, in terms of course syllabi; schedules and routines; modalities; policies; and assignments and assessments. This list is not comprehensive and is limited only by the creativity and empathy of individual instructors.

2 Implementing the Empathetic Course Design

To help implement the Empathetic Course Design Perspective, we provide a practical, instructor-facing template to promote better educational experiences for both instructors and their students. While many of our recommendations are consistent with inclusive teaching practices (e.g., self-awareness, empathy for students, awareness of students' unique backgrounds; Makoelle 2019; Dewsbury, Murray-Johnson, and Santucci 2021), we share how we promote empathy within our courses. Throughout this commentary, we describe how we have operationalized the infusion of empathy in our teaching practices in the courses we teach and discuss the pros and cons for each idea we present, but ultimately recommend instructors adopt these practices. Again, although we present these recommendations within the context of applied and/or agricultural economics and business classes, this template may be applied to courses taught in any academic discipline, at all levels (e.g., lower- and upper-level courses) and in any modality (e.g., face-to-face, hybrid/hyflex, online). Although not every suggestion we provide may work for every course, we believe the overarching ideas can be applied to any course in ways that are consistent with and enhance the instructors' teaching practices. Further information can be found on our YouTube channel, Engage the Sage, in which we publish videos reiterating these points.

2.1 Empathetic Syllabi

One of the earliest and most salient ways empathy may be infused into courses is through the statements instructors include on their syllabi.[3] Course syllabi have the dual purpose of *informing* our students about the content, structure, and policies of our courses and *inspiring* our students by exciting them about the content and showing our engagement in, and support for, their learning (Slattery and Carlson 2005; Palmer, Wheeler, and Aneece 2016). Rather than being merely legalistic documents with mundane course information, syllabi can become empathetic contracts that create connections with our students by establishing trust and rapport. Indeed, we recommend instructors include statements on their syllabi that explicitly express their support for the core principles stated above, including their investment in the learning and success of their students. Specifically, we recommend including statements about instructors' commitment to and respect for DEIB in their explicit recognition of the value of every student, given that addressing DEIB issues has been identified as a challenge in agricultural and applied economics and businesses classes in recent years (e.g., Lambert Snodgrass et al. 2018; Wiersma-Mosley 2019). We also recommend including statements about instructors' respect for the physical and mental health and well-being of their students that both normalize challenges (e.g., mental health concerns) and provide information about campus resources (e.g., campus counseling services). Such statements communicate support to students on behalf of their instructors, which in turn can have positive effects on students' learning and well-being (e.g., Faulkner et al. 2021). We also recommend the explicit inclusion of an "empathy statement" on syllabi that invites students to reach out to instructors with any concerns they may have, or challenges they may be facing, such as the one below:

> *"Things are different now (during the COVID-19 pandemic) than they were. This is very real for all of us. The "social distancing" and transition to remote education is tough, and frankly it sucks. We are teaching differently and under different circumstances than we were, and you are learning differently and under different circumstances than you were. Please keep connected with us. If you have difficulty with the course content, assignments, deadlines, etc., please reach out and we will try to work with you as best we can. We want you to learn and succeed. We want to have a wonderful experience learning with you. We should be creating "physical distance" right now, not "social distance." We are here for you."*

While some instructors may fear students will take advantage of this empathetic approach, students have not abused it in our experience. Infusing empathy into teaching and course design should not be confused with leniency. Rather, we believe this approach provides students with the appropriate support to reach their full potential. It is also possible instructors make this statement (repeatedly) in their classes in lieu of adding such a syllabus statement. The goal is to ensure that students know they are supported throughout the entirety of the semester.

2.2 Empathetic Course Schedule and Routines

Our Empathetic Course Design Perspective can also be infused into the way courses are scheduled.[4] Instructors can provide support for their students by creating courses with explicit weekly routines (e.g., regularly scheduled emails and announcements regarding upcoming course events and assignments). This routine makes the communication and schedule of the course predictable and while some may criticize such a routine as boring or mundane, we argue it helps reduce students' stress and anxiety in the course because nothing is surprising, and there is consistent, supportive communication. Instructors can further support their students' success by having consistent, predictable due dates and times for assignments (e.g., Sunday evenings at 11:59 PM). This suggestion is particularly easy to implement with

[3] See the "Empathetic Syllabus Statements" *Engage the Sage* video.
[4] See the "Empathetic Course Structure and Policies" *Engage the Sage* video.

regularly scheduled, lower stakes assignments (e.g., weekly reflections). Our students told us this helped alleviate some of their anxiety because they were enrolled in more than one course, with multiple due dates to attend to. The course schedule can also infuse empathy by proactively scheduling mental health days, prep days, catch-up days, and/or reading days when the course responsibilities are heavier and/or when instructors anticipate students will need a break. Further, the schedule can be designed empathetically to spread out the course work and assignments over the course of the semester evenly to avoid the buildup that often occurs in the final weeks of the semester.

2.3 Empathetic Course Modalities

The course structure itself, in terms of the modality in which the course is taught, allows instructors to infuse empathy. Despite the physical closings of college campuses around the world due to COVID-19, institutions were still able to serve their students through technologically mediated forms of teaching (e.g., remote/hybrid models; Adedoyin and Soykan 2020), which may become the "new normal" beyond the pandemic in higher education (see Benito et al. 2021). Thus, instructors may design their courses to teach students "where" they are (literally and figuratively). Teaching classes using hyflex teaching modalities (i.e., students may attend in-person, online synchronously, or watch posted videos of class later asynchronously) may be an empathetic option that addresses issues when students are unable to attend class in person (e.g., when students contract COVID-19 and must isolate) or in real time (e.g., family emergencies). In our experience, students appreciate having the option to view class recordings, even if they did not miss class but wish to revisit content on their own time. There is admittedly a greater degree of technological fluency and proactive output of work in setting up hyflex classes, and this may not work for all classes (e.g., labs that require "hands on" interactions). It is also possible that instructors experience lower engagement from students when teaching in a hyflex modality; however, there are practical things that instructors can do to mitigate such challenges (e.g., well-structured courses, clear communication; see Heilporn, Lakhal, and Bélisle 2021). Thus, when possible and appropriate, this modality may alleviate many issues and needs for individual communication as the semester progresses.

If instructors employ online teaching methods, we recommend they have some synchronous contact with their students to allow for real-time connections and support (e.g., to check in on their learning and well-being; see also Woodcock, Sisco, and Eady 2015; Guo 2020).[5] When teaching online synchronously, we recommend inviting students to keep their videos on when possible and explaining to students why this is preferred. The statement below is a sample statement instructors may share with their students:

> *"For classes that you attend synchronously over Zoom, we expect you will attend with your video on. This will make it easier for us to connect to you and gauge your understanding while we teach. This will also make it easier for you to pay attention and be less distracted by other things. In short, if you attend with your video on, you will engage more in the class, learn more, and help us teach you better. We understand that you may be unable to attend with your video on for a given class for whatever reason—just please let us know."*

2.4 Empathetic Course Policies

Instructors may infuse empathy into their course policies by reframing existing policies and/or adopting new ones.[6] Instructors may adopt empathetic attendance policies that allow students to attend classes via different modalities (see above) or to miss a certain number of classes without penalty. Another opportunity for empathetic policies is with students' late and missing work. We recommend being flexible with assignment deadlines either by not punishing late work generally (e.g., Hansen 2021) or by

[5] See the "Empathetic Zoom Approach" *Engage the Sage* video.
[6] See the "Empathetic Course Structure and Policies" *Engage the Sage* video.

allowing a one-time free pass (e.g., Crocker 2021). Perhaps these policies recommend students preemptively request an extension in order to avoid a small penalty. Moreover, we have found that the quality of students' late work is usually not sacrificed by taking the extra time to turn in a better assignment. Another possibility is offering several possible deadlines for assignments because it allows students to spread out their work and instructors to spread out their grading. Not only can deadline flexibility help accommodate students with extenuating circumstances (e.g., illness, family emergencies), but it can also alleviate stress on behalf of the instructor. With respect to missing work, Cross, Frary, and Weber (1993) recommend excluding missing exams (i.e., zeros) from final grades, even if the student's absence was unexcused. Our later recommendation about offering exams online for a certain period of time (see section 2.5) may also help avoid the issue of physically missing an exam entirely. Finally, whatever instructors choose to do, we agree that instructors should be transparent about their late and missing work policies (e.g., Cross et al. 1993).

To more broadly infuse empathy into course policies, instructors may phrase their policies consistent with what we call "Choice to Learn," in which we frame the course as having no "requirements."[7] Instead, instructors inform students that they have earned no points yet at the start of the semester but will have "opportunities" to accumulate points over the course of the semester. These opportunities will manifest in the form of assignments, exams, papers, etc., and students may opt to complete these at their discretion. If they choose not to pursue an opportunity, they forfeit the chance to earn the points associated with that opportunity. This framing emphasizes that students earn, not lose, points throughout the semester as a function of their decisions and performances. Instructors facilitate the earning of those points by offering opportunities and making recommendations, rather than making mandates. We believe this framing empowers students to take responsibility for their own grades (or focus more on the learning itself, as in ungraded classes; Ferguson 2013) and increases students' intrinsic motivation (see Ryan and Deci 2020) in completing their coursework, both of which are consistent with mastery learning approaches (e.g., Block and Burns 1976). Moreover, this framing situates instructors in the role of supporters who guide students, rather than gatekeepers who present obstacles to students receiving the grades they want.

2.5 Empathetic Assignments and Assessments

Perhaps the most impactful way instructors may infuse our Empathetic Course Design Perspective into their courses is through their assignments and assessments.[8] Instructors should remember that everything they assign will eventually come back to them for grading. Accordingly, we recommend creating assignments and assessments that students will *want* to complete, and instructors will *want* to grade. Student-centered assignments and assessments can help students demonstrate their learning successfully (e.g., Wright 2011), enhancing the experience of both students and instructors in the course (e.g., Saucier 2019b; Saucier, Schiffer, and Jones 2022).

One overarching way to make your assignments more empathetic is by making them challenging but not unnecessarily difficult. Given that there are a lot of negative consequences with high stakes assignments and assessments (e.g., decreased student motivation, higher dropout rates; Amrein and Berliner 2003), we recommend replacing such assignments and assessments with more frequent, smaller lower stakes assignments. For example, we often offer weekly reflection assignments for students to complete for points throughout the semester. While these assignments are not difficult, they allow students to meaningfully reflect on important content from that week in class, while also providing instructors with valuable information regarding what students are taking away from class. In our experience, students appreciate the opportunity to have more autonomy in their assignments and learning. These assignments are also more enjoyable to grade given that every student's reflection is

[7] See our "Emphasizing the Choice to Learn" *Engage the Sage* video.
[8] See the "Empathetic Assignments and Assessments" *Engage the Sage* video.

individualized regarding their understanding of the content, as well as how their personal experiences relate to that content. Another option is setting maximums (e.g., numbers of words or pages) that help students streamline their work, so their work is both higher quality and easier to grade. Ultimately, these changes made students' work more personalized and streamlined, which improved our grading experiences.

We also offer students choices in what they do and when they do it. Specifically, we have offered students autonomy for assignments, namely in what we call "missions" (see Saucier, Schneider et al. 2022). Specifically, students are given social objectives to achieve for each mission (we typically assign one mission per week in each semester), where they consider and apply course content in individualized ways (e.g., identifying social bias online and using course knowledge to challenge it; Saucier, Schneider et al. 2022). This type of social mission likely builds ties between undergraduate students, the university, and the community, which is especially important for economics students (Pereira and Costa 2019). The majority of students' time spent on these missions is spent promoting social change and justice, rather than writing the mission report. Mission reports are streamlined and, therefore, easy to grade. Overall, we have had success with these missions; our students complete these missions at high rates, perform well on them, and report they are valuable (Saucier, Schneider et al. 2022).

For empathetic assessments, we recommend exams that would traditionally be held in person instead be offered online at times students choose for themselves (and cancel class so students still have "class time" to complete it; see Saucier, Schiffer, and Renken 2022). Some may argue that academic dishonesty is a bigger challenge for exams administered online versus in person (e.g., King, Guyette, and Piotrowski 2009). However, the data collected from online exams actually makes it easier to identify academic dishonesty with timestamped submissions and information on students' patterns of responding (e.g., order of question completion). Nonetheless, we allow students to use their resources (e.g., class notes) while completing exams to avoid issues like test anxiety that are common with traditional in-class exams (e.g., Zeidner 2010). In this case, the design of our exams becomes more application-based (rather than vocabulary memorization), which requires higher levels of critical thinking and is ultimately better for learning (e.g., Snyder and Snyder 2008). We also advocate for limiting the use of comprehensive assessments to only when classes build comprehensive skills over the course of the semester.

Another option for empathetic assessments is implementing what we call, "Exams by You" (see Saucier, Schiffer, and Jones 2022) in which students create and complete their own exam questions for a specific academic unit. Importantly, "Exams by You" can be scaled as needed. For instance, in our more advanced courses, exams are exclusively "Exam by You" questions, with students generating ten questions and responding to them in paragraph form. In our introductory courses, exams employ a combination of a more traditional format (e.g., multiple choice) with perhaps two "Exam by You" questions that students write and answer. We use "Exams by You" differently based on class size (e.g., 30 students vs. 200 students), the level of the course (e.g., advanced vs. introductory), our expectations of students' critical thinking abilities (e.g., first-year students vs. majors in the area), and students' ability to both apply content and formulate reasonable exam questions. Admittedly, this exam approach was, initially, more difficult to grade due to the idiosyncrasies of each student's exam. However, this also makes academic dishonesty more easily identifiable. More importantly, student-written exams allow for student creativity and personalization (Corrigan and Craciun 2013), which enhanced our personal grading experiences.

3 Call to Action

Above, we have detailed several minor changes that can make your courses more flexible and empathetic. We acknowledge there are several reasons why instructors may have not yet adopted these perspectives. Instructors may be hesitant to implement these strategies out of fear of being perceived as lenient, fear of students abusing their "benefit of the doubt," and/or the fear of straying away from long-standing, traditional teaching practices. However, we believe the benefits of the Empathetic Course Design Perspective far outweigh the (minimal) costs of its implementation. In addition, empathy is more important than arbitrary rigor.[9] Upon implementing our Empathetic Course Design Perspective, in our experience, we have seen benefits for both instructors and students. Benefits for instructors include having a more supportive structure for our teaching practices, allowing us to teach better and subsequently enjoy the experience more. Through TDE (Saucier, Miller et al. 2022), benefits for students include having a more inclusive and safe learning environment, ultimately helping them learn more and demonstrate their learning better. In short, the Empathetic Course Design Perspective creates a more positive, successful, and fulfilling experience in the course for both instructors and students. Beyond instructors taking it upon themselves, we also encourage teaching and learning centers to advocate for our Empathetic Course Design Perspective by including it in the professional development of instructors (Saucier et al. 2021).

4 Conclusion

We explained the need for more empathy within our courses, identified our solution as the Empathetic Course Design Perspective, and provided practical ways instructors can infuse this perspective into their courses. Recall, we argue that the process of infusing empathy (and engagement) begins with the instructor (i.e., TDE; Saucier 2019b; Saucier, Miller et al. 2022), who should be deliberate in the development of their teaching persona (e.g., PEACE; Saucier 2019a; Saucier and Jones 2020) and practices (e.g., empathetic course design). These infusions should be discussed explicitly with our students to explain and normalize these empathetic teaching practices. We believe the infusion of these principles into one's agricultural and/or applied economics and business courses will create a more positive and inclusive classroom environment. By intentionally infusing empathy throughout our courses, we have the potential to promote more successful and fulfilling teaching and learning experiences, thereby maximizing the engagement and experiences of both students and instructors.

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[9] See our "The Problem with Academic Rigor" *Engage the Sage* video.

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