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The Battle for Space Supremacy… an Application of Pricing and Market Structure

This article illustrates and outlines a series of activities that undergraduate economics professors could use to introduce their principles and upper-level students to topics related to production economics, price discrimination, market structure, and game theory using a timely example and readily identifiable characters. The exercises are autonomous and may be used in isolation. The main characters are Elon Musk (CEO of Tesla and SpaceX) and Jeff Bezos (CEO of Amazon and Blue Origin). The objective of this classroom activity is to work through a hypothetical example of what competition between SpaceX and Blue Origin may look like as they compete in the future for commercial space supremacy. Moreover, the learning activities in these exercises are structured in a way that encourages students to participate in a given activity first and then reflect on what they did and how they could have improved their outcome or profitability by applying analysis and economic thinking. Students watch videos before the exercises to flip the classroom.

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1. Introduction

The objective of this paper is to illustrate and provide an example of economic content that has been applied in a relevant and timely setting using celebrity CEOs (i.e., Elon Musk and Jeff Bezos) who are currently engaged in exploring production in an emergent industry. Through these activities, we provide students with a setting to explore concepts related primarily to market structure but have applications that are relevant to production economics, price discrimination, market structure, and game theory. Karlan (2017) indicated that "When teaching economic principles, we should aim to include not merely 'real' examples throughout, but engaging ones that relate to students' everyday life or desire to improve the world around them" (p. 228). Further, the activities were created using a market that is yet to emerge, but one we could potentially experience in the future (i.e., a space race to Mars) to ensure that the timeliness of the activities will stay relevant for several years. Moreover, the basis of these activities could be implemented in sections and be presented over a few sessions, or instructors could use the content and focus on a specific topic that suits their course's needs.

These exercises could encompass multiple classes across Principles of Microeconomics, Price Theory, and Game Theory courses. Each exercise builds on the previous and starts with rudimentary concepts to more complex. The exercises have components completed outside class allowing the classroom to be flipped and student-faculty interaction to be more efficient. Students can post their answers using software such as Socrative.com to allow the class to see the work of others and identify patterns in student responses. The exercise may be used in isolation or combined for a semester-long project. Table 3, in Appendix 1, outlines the activities associated with the case.

2. Literature Review

Watts (2003) suggested that economics has been traditionally taught using the historical chalk-and-talk method, and, as a discipline, it seems as though we are not properly conveying how interesting and relevant the study of economics. In a follow-up paper, Watts and Becker (2008) suggested that there is evidence economics professors rely more on lecture than other techniques to deliver their content and that economics classes offered fewer interactive forms of learning. Watts and Becker (2008) suggested that from their 2000 and 2005 survey results they found evidence that newer professors who are familiar with applying technology in other aspects of their lives seem to be applying more presentations, internet searches, and experimental economics in their courses, which is something many encourage.

Harter, Schaur, and Watts (2015) found that there is evidence the use of lecture as a primary teaching tool is decreasing, cooperative learning techniques are being used more frequently, computer-based presentations are increasing, and the use of workbooks in classrooms are decreasing (p. 1181). These findings lead to a very interesting question as we attempt to move our classroom experiences from a more chalk-and-talk type of delivery system (i.e., objectivist approach) to one that embraces more cooperative learning strategies and case exploration (i.e., cognitive approach)—how do we ensure that our students are learning the basics to grapple with the more challenging and divisive issues? This paper outlines one approach teachers could implement to capture the students' interest and to potentially motivate them to explore foundational economic concepts in an applied setting.

Navarro (2015) questioned how economics faculty can survive in a new world of online Massive Open Online Courses (MOOCs) and led the reader through a survey of the literature that indicates students are bored with lectures and they find that PowerPoint presentations often are the most important contributor to their boredom. Moreover, students stated that the 'least boring' methods of instruction seem to have a seminar approach, practical applications, or group work in which students can actively participate in the sessions. The advice that Navarro (2015) provided is to take this transition to the virtual world seriously and identify ways to differentiate yourself from other educators. In this activity, we are going to provide students with an innovative approach to delivering the traditional chalk-and-talk material that enables them to think critically about the problems that traditional economic concepts aim to solve in an applied setting (Raboy, 2017).

Student-centered learning encompasses active learning, employs cooperative learning, and holds students accountable for their learning (Felder & Brent, 1996). It complements flipping the classroom. Active learning is a shift from passive, instructor-focused learning to engaging classroom participants through debates, discussions, games, problem sets, polls, cooperative learning, etc. (Cavanagh, 2011; Harris & Cullen, 2008; Miller & Metz, 2014). Compared to lectures, active learning enhances critical thinking and improves student engagement, self-directed learning, and motivation (Cavanagh, 2011; Lumpkin, Achen, & Dodd, 2015; Miller & Metz, 2014). Bonwell and Eison (1991) summarized cogently the benefits of active learning: "When the objectives of a course are for students to retain information after the end of the course, to be able to apply knowledge to new situations, to change students' attitudes, to motivate students toward further learning in the subject area, or to develop students' problem-solving or thinking skills, however, then discussion is preferable to lecture" (p. 36).

To attempt to move from the traditional chalk and talk method, this paper illustrates an alternative to this method and an application of economic thinking to solve a series of problems emphasized in a case analysis. Ray (2018) studied two sections of an upper-level course in economics and found that the use of cases, based on both a quantitative and qualitative basis, improved students' academic achievement in the classroom. Further, support for this approach is provided by Emerson and English (2016a), who measured the effectiveness of using classroom activities to enhance their students learning experience and test scores for 880 students participating in 28 sections of Principles of Microeconomics courses at Baylor University from 2002 to 2013. They found statistically significant evidence that the classroom activities did have a positive effect on student learning outcomes (this sentiment was reiterated by Allgood, Walstad, & Siegfries, 2015; Emerson & English, 2016b).

Given that case analysis takes away time from more traditional approaches to transferring knowledge or information to students, some discussion around inverting the classroom is necessary. The inverted or flipped classroom forces students to complete traditional lectures outside the class and affording more student control to review material and practice application at their pace. External material replaces the traditional lecture or supplements it by providing additional examples. Inquiry-based learning then dominates class time (Barkley, 2015). Instructors flip the traditional model of classroom lecture outside of the class and have students work on homework, discussion, collaboration, and problem-solving inside of the class (Bergmann & Sams, 2014; Hoffman, 2014). Wilson (2013) defines it as "moving the typical 'transmission of knowledge' component of a class (i.e., lectures) to outside of the classroom and moving the 'application of knowledge' (i.e., homework) into the classroom" (p. 194). The flipped classroom has been shown to increase pass rates, improve engagement, generate cooperative learning, and allow greater individualized attention (Bergmann & Sams, 2014; Strayer, 2012). Using engagement theory as a theoretical underpinning, shows students learn by doing and internalize learning with engaging activities (Perez et al., 2019) and case studies (Jones & Baltzersen, 2017).

3. Classroom Applications

In subsection A below, motivation as to why students will be interested in a space tourism example and background information is provided to explain some necessary costs that are utilized in follow-up activities. In the remaining subsections (B - I), there will be a brief note on Learning Objectives, Instructions to Students, and Commentary to guide. Subsection B asks students to complete background research on Musk and Bezos and their companies that leads to class discussions, while the rest of the subsections outline in-class activities and applications. The commentary in each subsection notes rubrics or worksheets to hand out for these activities which can be found in the appendices. Table 1 below outlines the activities and the course where it applies.

Table 1: Activities Outline

Subsection	Topic	Course
B	**Self-Interested Behavior**	Principles of Microeconomics
C	**Demand Estimation**	Principles of Microeconomics
D	**Production Economics**	Principles of Microeconomics
E	**Market Equilibrium (Perfect Competition)**	Principles of Microeconomics
F	**Monopolist's Output and Price**	Principles of Microeconomics
G	**Perfect Price Discrimination**	Principles of Microeconomics
I	**Duopoly - Game Theory (Simultaneous and Sequential Play)**	Principles of Microeconomics
H	**More Advanced Duopoly Analysis (Cournot, Stackelberg, & Bertrand)**	Intermediate Price Theory

A. Background Information and Motivation

Selding (2016) indicated that the direct cost for a space launch, based on a decomposition of the costs and gross margin markups on SpaceX's launches, is $36.7 million for a Falcon 9 launch (this includes the launch campaign and the fuel) assuming that the company passes on all of the savings that the company is likely to extract from reusable rockets. This all-in cost estimate allows us to imagine how much it might cost to fly another mission, one that is on Elon Musk's agenda. According to McFarland (2017), people are willing to pay a lot to travel to space. The report by McFarland (2017) stated that Elon Musk, of SpaceX, already has significant deposits from travelers who are seeking to travel to space and that earlier trips have cost upwards of $20 million (the U.S. Government actually paid $80 million a seat to send astronauts to the space station). We are assuming for illustrative purposes that competition will drive costs down and, perhaps, we will be left with a similar cost structure that Selding (2016) provided when Elon Musk is finally able to send passengers to Mars. This $36.7 million cost per flight will be used in subsections E, F, and H that follow.

As for why these activities will connect to college-aged students, there appears to be an interest in space tourism for younger generations. While a majority of Americans say orbiting earth is not for them, 63% of Millennials surveyed by Funk et al., (2018) note they are definitely or probably interested. According to Sheetz (2019), UBS estimates that high-speed travel via outer space will represent an annual market of at least $20 billion, compete with long-distance airline flights, and that space tourism will be a $3 billion market by 2030. That means that even if students are uninterested in traveling to space themselves, there will be jobs available in this area.

B. Self-Interested Behavior

Learning Objective:

Illustrate how self-interested behavior leads markets to efficient outcomes.

Instructions to Students:

1. Self-Interested Behavior & Market Efficiency: For homework, you will be assigned to either Team Bezos or Musk. You must research your assigned American entrepreneur through reputable third-party objective business sources. Your research will include the space industry over the last 10 to 15 years and how it is transitioning from a publicly-funded to a privately-funded industry as companies similar to SpaceX and Blue Origin have focused their attention on the potential profitability associated with commercial space flights. Your written report, one per group, must include at least six sources from the last three years. You must include in your answer a review of the following video: https://www.youtube.com/watch?v=ulyVXa-u4wE. What follows are two vignettes that should provide you with a brief introduction to the two entrepreneurs, Elon Musk is presented first and then Jeff Bezos:

    a. Elon Musk studied physics and economics at the University of Pennsylvania (Sugar, 2015). According to Vance (2017), fresh out of college, Musk founded Zip2 that was a primitive version of a combination of what Google Maps and Yelp would become, and sold his portion for $22 million. He put this money into another startup that would eventually be transformed into PayPal (Vance, 2017). In 2002, eBay acquired PayPal for $1.5 billion and from the payout that Musk received from PayPal he invested $100 million into SpaceX, $70 million into Tesla, and $10 million into SolarCity (Vance, 2017). Vance (2017) emphasized that the Musk Empire of companies has made him one of the wealthiest men in the world with a net worth of approximately $10 billion. But "Musk's ultimate goal…remains turning humans into an interplanetary species" (Vance, 2017, p. 331) and he has dedicated his life to reach this objective. In Vance (2017), Elon provides us with some perspective about how we might be able to colonize Mars. He claims that at a cost of $1 billion per person it is not achievable, but at a cost of "around $1 million or $500,000 per person, I think that there will be a self-sustaining Martian colony" (p. 333). Vance (2017) highlighted what might be Musk's most effective but also most harmful personality trait, which is the lack of loyalty or human connection; further, that people that had worked for Musk for years would be discarded like pieces of litter and that people "were like ammunition: used for a specific purpose until exhausted and discarded" (p. 340). Both internal and external competition seems to drive the Musk Empire of Companies forward to envision new ways to disrupt old industries and through this disruptive process, create new and emergent technologies.

    b. Jeff Bezos, on the other hand, according to Stone (2014), finished college at Princeton in 1986, where he studied computer science and electrical engineering. When he finished college, he found jobs with various financial firms including D.E. Shaw before starting a company. This company eventually turned into the behemoth online retailer and technology company that Stone (2013) refers to as 'The Everything Store,' but more conventional outlets call Amazon. Zhu and Liu (2018) outline the vast nature of Amazon's operations, from retail, to web services, to fulfillment, to entertainment, and other business units; Amazon is a lot more than a retailer, it is a technology company that has revolutionized how we think about retail. Recently, according to Streitfeld (2018), the valuation of the Amazon business exceeded $1 trillion, which made it the second company in US history to accomplish this feat. A question that could be asked for you to consider is how did Amazon obtain a valuation of 1 trillion dollars? You could think about Amazon's Leadership Principles and how those principles translate into economic principles. What impact do leadership principles like customer obsession, ownership, insisting on the highest standards, having a backbone and encouraging disagreement, and a focus on delivering results (Amazon.com, Inc., 2019) have on a company? At least for this company, it has created a differentiated product that people choose to consume. However, as Kantor and Streitfeld (2015) outlined, inside the company the competition is fierce, which is evidenced by Robin Andrulevich's comment who is a former top Amazon human resources executive, that stated Amazon uses 'Purposeful Darwinism,' to encourage people to become "athletes with endurance, speed, performance that can be measured and an ability to defy limits" and that "Amazon is where overachievers go to feel bad about themselves." At the same time, however, it seems as though based on employee satisfaction surveys, the Amazon employees that remain at the firm prefer this type of work environment and a culture that seems to be relentlessly focused on the consumer (Cao, 2018).

<u>Commentary:</u>

We researched Elon Musk and Jeff Bezos's backgrounds by reading, among other documents, Stone (2014) and Vance (2017). Since the CEOs' successes and failures are regularly changing, instructors should research material before class. The brief introductions to the CEOs included in our activity serve a few purposes. To start with, they illustrate how the pursuit of self-interest can ultimately lead to better outcomes for society. Imagine a world without Amazon, Tesla, Solar City, PayPal, SpaceX, and Blue Origin and think about how these companies have fundamentally changed the world and how they have changed all of our expectations about the future. Second, they provide students with a 'starting point' to explore the two entrepreneurs and their backgrounds. During class, students highlight their findings and we discuss the societal benefits of self-interested behavior from these preeminent entrepreneurs. The self-interested discussion should take 30-minutes. Finally, in Appendix 2 a rubric is provided that we used to score the writing assignment.

C. Demand Estimation

<u>Learning Objective:</u>

Develop a demand curve, given bids from different customers for space flights.

<u>Instructions to Students:</u>

You are going to be given the bids and names of four potential customers that are interested in traveling to Mars. Your goal is to estimate the relationship between quantity demanded and price using your understanding of the Law of Demand and assuming that there is a linear relationship between price and quantity demanded. Using four bids and the rank of those bids (i.e., where they fall on the demand curve), plot the points and estimate the linear demand curve for Elon Musk's space flights. What is the relationship between price and quantity?

<u>Commentary:</u>

The goal of this section is for the students to estimate a demand curve based on the information provided below. Instructors could partition the class into groups of three to four students and have them estimate the demand curves individually, given just four data points from Table 2below.

Table 2: Data for Demand Estimation

Name	Bid	Name	Bid
1. Richie Bee	$60,000,000	11. Wilber Orville	$40,000,000
2. Mr. Yakuza	$58,000,000	12. Buzz 'Light-year'	$38,000,000
3. Galilei Star	$56,000,000	13. Astroguy	$36,000,000
4. Joy Brangelina	$54,000,000	14. Jeffy Preston	$34,000,000
5. Deuces Bigelow	$52,000,000	15. Tyler the Martian	$32,000,000
6. Axton Butcher	$50,000,000	16. Kiko Santiago	$30,000,000
7. Hawk Ing	$48,000,000	17. Lenny Strongarm	$28,000,000
8. Joe Roganowski	$46,000,000	18. Mikey Tyson	$26,000,000
9. Bob Jackson	$44,000,000	19. Perry Kay	$24,000,000
10. M&M Biebs	$42,000,000	20. Leo the Tiger	$22,000,000

Students only need an understanding of the slope-intercept form of a linear relationship. Alternatively, to make the exercise more challenging, we suggest leaking the names/bids within minutes during the same class, in random order, and inform them that Elon Musk would like them to provide a linear estimate for the demand for space flights. Based on this information and the information provided in Table 3, students should be able to estimate the inverse demand (marginal benefit) curve for space flights of Price = $62MM - $2MMQ, which will be used in the remaining sections.

This activity and discussions should take 20 to 30 minutes of classroom time. The following videos should be used to supplement the activity and to ensure that students come into the session with an intuitive understanding of the material: The Demand Curve. Marginal Revolution University. URL: https://youtu.be/kUPm2tMCbGE | Demand and Supply Explained- Econ 2.1. Jacob Clifford - ACDC Economics. URL: https://www.youtube.com/watch?v=LwLh6ax0zTE. Finally, in Appendix 3, a worksheet is provided that we have used to estimate the demand equation.

D. Production Economics

<u>Learning Objective:</u>

Simulate the production runs to see how the number of space stations (capital) leads to increasing, then diminishing, and finally negative marginal productivity, given the constraints.

<u>Instructions to Students:</u>

You should assume that each second of the 30 seconds allotted is a 12.67-days, which would make the duration of the time associated with the activity a year in length. Place Earth and Mars markers approximately 10 feet apart to simulate space travel. Spacecraft travel is simulated by moving a ball from Earth to Mars. Allow the number of students (i.e., space stations) to fluctuate from one to five by incrementally adding another student to the simulation.

Commentary:

Admittedly, this is where we mix a bit of science with science fiction in a way to develop an activity. Students can see how adding additional space stations will yield increasing and then decreasing marginal productivity with regards to the number of flights possible.

We currently use a kickball to simulate a space flight similar to Hedges (2004) (i.e., students either run a ball back and forth from Earth to Mars or students throw the ball back and forth, depending on how many space stations they have decided to deploy). The key to running this activity and generating results that illustrate increasing and decreasing returns associated with a factor of production is that the spacecraft has to dock at each space station over each leg of the journey. Note, that as you add each additional person into this activity, he/she would have to be considered a 'space station' and the ball would have to land at each space station before it could move to the next in a sequence.

In its simplest form in our segment of production economics, we take the standard production function, , where Q is output (i.e., trips to Mars), K is capital invested (i.e., the number of operational space stations that we have at any given time), and L is labor employed throughout the system (this input is considered fixed for simplicity). In this activity, we assume that we receive some increase in the speed we travel from each stop, but the stop also takes time. As we move from one space station to two, in the activity, the students should be experiencing increasing returns to the additional unit of capital deployed in the trip to Mars. The addition of the third station, all else constant (i.e., no learning effect), typically results in some diminishing marginal returns to a factor of production. Eventually, if enough space stations are added, we would experience negative returns associated with that factor and realize that the additional deployment of capital is negatively affecting our space travel businesses.

In addition, the following videos could be used as pre-class resources to expose the students to concepts related to production economics: The Tennis Ball Games. Rutgers Today. URL: https://youtu.be/J2RCg3ctZsA | Total product, marginal product, and average product | AP® Microeconomics. Khan Academy. URL: https://youtu.be/8fm9FjDV0iA. Finally, in Appendix 4 a worksheet is provided that we have used to log the total and marginal production associated with each number of space stations deployed.

E. Competitive Output

Learning Objective:

Have students reflect on their production decisions and illustrate what an individual firm, call it SpaceX or Blue Origin, would do if it were to produce the competitive output. Additional activities: Identify the consumer surplus and producer surplus available in a competitive industry.

Instructions to Students:

To begin to understand how Musk, the market leader, should approach his output and pricing decisions, let us calculate what the output and price would be in this industry as profits approach zero. To accomplish this, you could simply set the industry supply curve equal to the industry demand curve and calculate the market-clearing quantity. After this is done, solve for the market-clearing price. However, it is better to 'see' what is going on behind the scenes; therefore, your instructions are to calculate the price, total revenue, total cost, and profits associated with each level of output and then determine where the market-clearing price and quantity is—after this, set supply equal to demand to confirm what you found.

Commentary:

When running the production activity, students typically overproduce unless they have additional information. This comes as the result of the students' natural competitive instincts to outperform the other groups. Having the students graph the demand and the marginal cost allows them to discover any errors in their previous interpretation of the problem and to begin to understand where the competitive output and price are found.

The students need to have an understanding of where the competitive equilibrium is reached before they can generate an understanding of the market power that the monopolist can exert over the marketplace. Therefore, in this activity, it is useful to highlight where the competitive equilibrium is and the consumer and producer surplus that are obtained throughout society by allowing or encouraging firms to produce at this equilibrium. It is also important to illustrate that the firms are making zero economic profits.

The students should use the information they obtained from the exercise related to demand estimation to solve for the market-clearing price and quantity that a firm would produce at the competitive equilibrium. The competitive output is found where marginal cost intersects price, which occurs at 12.65 space flights (i.e.,). In Appendix 5, we provide a worksheet for the students to work through and in Appendix 7, we provide an illustrative comparison of the competitive firm and the monopolist. The following videos should reinforce the concepts needed to understand what is implied by producing at the competitive equilibrium: The Equilibrium Price and Quantity. Alex Tabarrok (Marginal Revolution). URL: https://mru.org/courses/principles-economics-microeconomics/equilibrium-price-supply-demand-example | (Stop at 4 minutes) Does the Equilibrium Model Work? Alex Tabarrok (Marginal Revolution). URL: https://youtu.be/1PP85wxHROg.

F. Monopolist

Learning Objective:

Have students reflect on their production decisions and illustrate what an individual firm, call it SpaceX or Blue Origin, would do if it were the only firm to have access to this market. Additional activities: Identify the Deadweight Loss (DWL) that occurs from a monopoly and what happens to consumer and producer surplus under the same conditions.

Instructions to Students:

At this point, Musk's team should consider what level of output it should produce to maximize profit if it were a monopolist. In the last section, under competitive conditions, you set supply equal to demand and calculated total costs, total revenues, and profits associated with each level of output. It is important to obtain an understanding of what adjustments the monopolist would make to maximize profits. Add marginal revenue and marginal cost to your table. Identify at what point Musk would maximize profits if he were the only firm to offer space flights. At this point of production/output, what do you notice about marginal revenue and marginal cost? Also, consider what happens to the consumer and producer surplus at this level of production.

Commentary:

Students are asked to consider what quantity the monopolist should produce given its market power. It is useful to compare and contrast the competitive equilibrium to the monopolist's profit-maximizing output to illustrate how much harm both the society's and consumers' experience as the market structure changes. Diagrams representing the DWL to society, consumer surplus transferred to producer surplus, and the overall reduction in surplus for society will naturally lead to discussions about regulation and industry concentration, which ties in well to the section on duopolistic competition. In addition, questions about pricing transparency in an industry like this will lead nicely into the section on price discrimination.

The students should be introduced to the marginal revenue curve and use that curve to determine the quantity of production at which marginal revenue intersects marginal cost. This is the quantity at which the monopolist will choose to produce. In addition, while they are graphing the monopolist's quantity and price, it is useful to have a graph that already highlights the competitive equilibrium so that the students can gain a visual appreciation of the concepts of DWL, consumer surplus transferred to producer surplus, and the effect that monopolists have on the total welfare for society. The following videos should reinforce the concepts related to monopolies: Office Hours: Calculating Monopoly Profit. Mary Clare Peate (Marginal Revolution). URL: https://youtu.be/FiQsdBWEaMI | Monopoly Graph Review and Practice- Micro 4.7. Jacob Clifford (ACDC Economics). URL: https://www.youtube.com/watch?v=ZiuBWSFlfoU. Finally,. in Appendix 6, we have provided the worksheet that students should complete to determine the monopolist's output and price. In Appendix 7, we have provided a visual illustration of the price, quantity, total revenue, total cost, and profits for the monopolist and have compared them against the competitive equilibrium and in Appendix 8, we have provided calculations associated with determining the output and price that the monopolist should use to maximize profits.

G. Perfect Price Discrimination

<u>Learning Objective:</u>

Provide an example that illustrates the concept of price discrimination (in this case we are illustrating first degree, perfect price discrimination).

<u>Instructions to Students:</u>

Now that you are aware of what price and output combination the monopolist would choose if price was public information, what would happen if Musk kept the information on pricing private? For this activity, assume that Musk uses a private ballot bidding contest to select the first, second, third, and so on, passengers for space travel. He could then charge them the maximum price that they are willing to pay, based on that bid, to travel to Mars. What would Musk's profits be under conditions of perfect price discrimination?

<u>Commentary:</u>

In this case, we are assuming that Musk has perfect pricing information through a 'blind auction' process. If we take \$62 million - \$36.7 million * 12.65 * ½, we obtain \$320.05 million that is available for our monopolist to extract that should be able to be transferred to producer surplus if we are to assume perfect price discrimination. However, in this example, the producer is only able to extract \$147 million of the \$320.05 million in consumer surplus. We highlight this by providing our students with the following worksheet and the associated instructions provided in Appendix 9

To illustrate the difference between the profits that our monopolists would obtain if the information was publicly available versus what they might do in a setting in which they used perfect price discrimination, we devised an activity centered around the idea that Musk, is the first entrant to the marketplace, could use a blind bidding contest (i.e., sealed envelope) to determine the prices that he charges each pair of space travelers and how much quantity he sells. Given the astronomical price and prestige of being one of the first to participate in these types of flights, let us assume that bidders have no reason to bid anything below their true value. What we would like for the students to begin to understand is that, under conditions of first-degree price discrimination, the producer is attempting to extract the consumer surplus and retain it for themselves (i.e., similar to what occurs at a car dealership). This example is important because it illustrates the nuances that consumers and producers face under conditions of first-degree price discrimination. Also, how the lines are blurred between third-degree price discrimination and first-degree price discrimination as information collected on people's searching habit is allowing retailers to customize targeted offers that are trending towards first-degree price discrimination, but are wearing a veil of third-degree price discrimination (Griswold, 2017; Howe, 2017; Khan, 2017; Useem, 2017).

The following videos should reinforce the concepts needed to understand concepts related to price discrimination: Introduction to Price Discrimination. Tyler Cowen (Marginal Revolution). URL: https://mru.org/courses/principles-economics-microeconomics/price-discrimination-examples-airlines-arbitrage | Micro 4.8 Price Discriminating Monopoly (First Degree). Jacob Clifford (ACDC Economics). URL: https://www.youtube.com/watch?v=s3wFJHIuJPs. Finally, in Appendix 9, we have provided a worksheet for the students to solve for the consumer surplus that the monopolists can extract under conditions of perfect price discrimination and a visual illustration of the result of this activity.

H. Duopoly - Game Theory

Learning Objective:

Students should learn how to solve simultaneous and sequential move games using concepts and strategies related to game theory.

Instructions to Students:

You are assigned to either Team Musk or Team Bezos and presented with two scenarios. Scenario 1 is presented in Figure 1 and is an example of a simultaneous move game. Both you and your competitor are tasked with determining your optimal strategy for a one-shot game without collusion and with collusion. Discuss your selections and the profit for both parties. If you had to play the game again, would you choose a different option? Scenario 2 is presented in Figure 2 and is an example of a sequential move game. In this particular game, Team Musk has to choose its strategy, and then Team Bezos can choose its strategy. What strategy would you choose and why? Discuss the results of the game with your opponent.

Commentary:

The underlying principles that we would like our students to take away after running through these activities are the two general tenets of game theory-- never choose a dominated strategy and put yourself in your opponent's shoes. Students can leverage these rules to work through payoff matrices, identify a dominant strategy, and the Nash Equilibria, as well as using backward induction to solve a sequential move game. The following videos should reinforce the concepts related to game theory: Oligopolies and Game Theory-Economies #8: The Dark Knight. Jacob Clifford (ACDC Economics). https://www.youtube.com/watch?v=JMq059SAQXM | D.8 Subgame equilibrium, Game Theory - Microeconomics. Policonomics. URL: https://www.youtube.com/watch?v=8fCEfbx5ECE. Finally, in Appendix 10, we provide a worksheet to illustrate why the two firms are unlikely to act as a monopolist and produce at the monopolist's output that we call the 'Incentives to Cheat' activity.

The necessary background information needed to support these activities is found in the following subsections: (a) Teaching Notes: Simultaneous Move Game and (b) Teaching Notes: Sequential Move Game.

Teaching Notes:

Simultaneous Move Game

An additional session could be incorporated to discuss concepts related to game theory. Below a Prisoner's Dilemma scenario is outlined using the duopoly calculations with cooperative action to limit flights and maximize joint profits versus the dominant strategy to choose four flights and maximize individual profits. This allows students to better visualize the connection between these reaction functions and the simplified game matrix to analyze using best-response techniques. The resulting Nash equilibrium of four flights for Team Musk and four flights for Team Bezos reflects a no-regrets situation even though the three flights for both outcomes are better for both. Different applications of this basic problem or dilemma have been applied in many experimental settings (e.g., Khadjavi & Lange, 2013), and it is at times interesting to allow the students to grapple with the problem by comparing the tradeoffs and critically analyzing how they think their opponents will respond to this same dilemma. As Nash (1951) and Kuhn et al. (1996) point out, the notion of an equilibrium point in a two-person zero-sum game is identified by comparing that strategy to all other 'good' strategies. In this particular case, once we employ the general tenets of strategy, the solution makes sense; however, if taken alone, it leads to confusion because if collusion or cartel behavior was allowed, then another, higher equilibria could be obtained.

Figure 1: Prisoner's Dilemma

		Team Bezos	
		4 Flights	**3 Flights**
Team Musk	**4 Flights**	$37.2MM (Musk) / $37.2MM (Bezos)	$45.2MM (Musk) / $33.9MM (Bezos)
	3 Flights	$33.9MM (Musk) / $45.2MM (Bezos)	$39.9MM (Musk) / $39.9MM (Bezos)

Note: This figure provides a standard game-theoretic payoff table that could be used to illustrate the Prisoner's Dilemma and the differences between the competitive outcome and the collusive outcome.

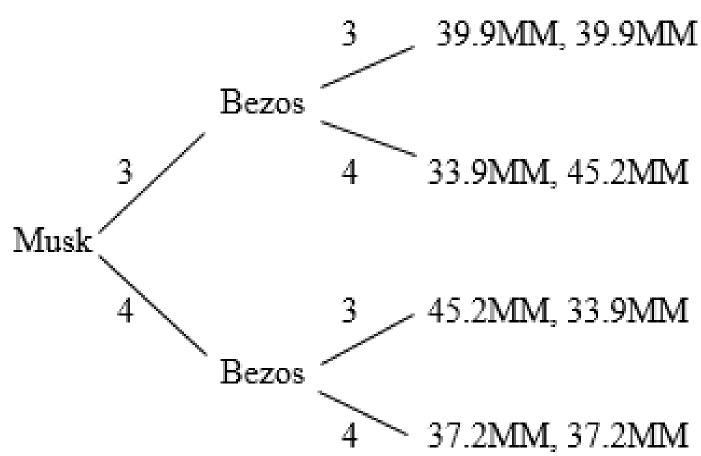
To further illustrate the idea behind the prisoner's dilemma and to help the students to understand why the 'best' result, which is for both parties to fly three flights, we use the exercise contained in Appendix 10. The activity titled Game Theory – Incentives to Cheat helps illustrate why each firm is motivated through self-interest to produce more output—all other things equal, assuming that both parties agree to set output equal to what is optimal under monopoly conditions, each party has an incentive to produce more to maximize their profits to the detriment of the other firm's profits and the profits available within the industry as a whole. Interesting applications of this idea are available in the literature, but the approach that we have used to highlight the outcome of the game is unique.

<u>Teaching Notes:</u>

Sequential Move Game

If instructors are interested in providing their students with an opportunity to analyze a sequential move version of the game, the following game tree can also be leveraged to illustrate that; in this case, even if allowed to move first, Musk would follow the dominant choice of four flights and that Bezos would observe this choice and also choose four flights. This would result in the sub-perfect game equilibrium for Musk: 4 flights at Node 1, and Bezos with four flights at Node 2 and four flights at Node 3 and an outcome of $37.2 million and $37.2 million. Similar to the one-shot game provided above, Muller and Tan (2013) compiled a total of 432 observations of strategic interactions between two individuals and groups that were given a simple game, like the one above. Instead of a payoff tree, they were given just the price function for the industry, assigned a role as the first- or second-mover in the marketplace, and were asked to select the quantity that they would produce. In these simulations of the Stackelberg duopoly, they varied whether individuals were playing or groups and the number of repeated trials that each treatment had to play the game. Interestingly, they found that the groups, over repeated trials, were far more cooperative when compared to individuals. Little tweaks or changes to the basic design of the activity enable the instructors to use the scenario to teach different concepts and allow students to learn through experimentation and gameplay.

Figure 2: Musk and Bezos – Sequential Move Game



Note: This figure provides a representation of a sequential move game and how to obtain a subgame perfect equilibria using the rollback or backward induction technique to solve the game.

I. More Advanced Duopoly Analysis

Learning Objective:

Enable students to begin to understand the strategic pricing decisions of a few firms in a competitive environment and the difference between the competitive market outcome and the collusive outcome.

Instructions to Students:

There are three different scenarios that you are going to have to explore that relate to competition in a duopoly. Under the first set of simulated events, both Team Musk and Team Bezos enter the market at the same time, and in the second set of simulated events team Musk is the market leader; they produced the monopolist's output in the preceding year. Under the first two conditions, both Team Musk and Bezos have to determine independently the output that they should produce without collusion. Repeat the exercise with collusion. In the final set of simulated events, each teams is allowed to provide a discount associated with the market price to attempt to capture market share up to $5MM per flight. For each of the simulated events run four to five trials and attempt to make generalizations about what both teams discover as a result of their interaction.

Commentary:

In this section, we have thought about many ways that teachers could engage their students to explore output and pricing decisions in duopolies. The first type would be simultaneous move games, and the second would be sequential move games. The following subsections outline the Cournot, Stackelberg, and Bertrand models of duopolistic competition. Teachers could provide the students with the demand curve and marginal cost estimates, but vary the activity in terms of the number of trials for the students to compete to 'reach' the desired outcome, alter whether the students compete as individuals, or manipulate whether students are given the 'best response functions' or payoff tables, among other things. These adjustments will be illustrated in the subsections below.

According to Correa, Garcia-Quero, and Ortega-Ortega (2016), "one of the most complex topics teachers must explain in class is the behavior of producers in oligopolistic markets" (p. 10) and that role-playing extends the theoretical treatment of these concepts and allows students and teachers to engage in deeper discussions about the applications of these concepts in an applied setting. The following subsections provide solutions to illustrate how Musk and Bezos would behave if we assumed that they followed either the Cournot, Stackelberg, or Bertrand models of duopolistic competition. It also illustrates how teachers could use different activity settings to help students discover these outcomes on their own and to understand why these theoretical arguments are valid.

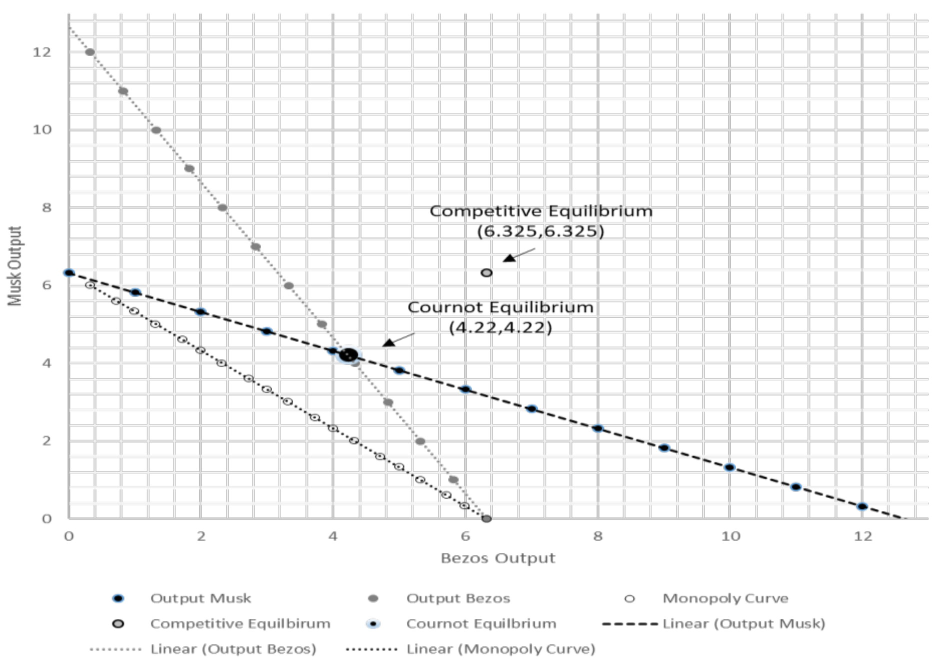
Additional background information needed to support these activities is found in the following subsections: (a) Teaching Notes: Cournot Duopoly (b) Teaching Notes: Stackelberg Duopoly, and (c) Teaching Notes: Bertrand Competition. The following videos should reinforce the concepts related to duopolies: Cournot. Alex Tabarrok (Marginal Revolution). URL: https://youtu.be/8r8lKmaqt08. Finally, in Appendix 11, we provide the calculations associated with the Cournot solution, and in Appendix 12, we provide the calculations associated with the Stackelberg solution.

Teaching Notes:

Cournot Duopoly

As we allow 'Team Bezos' to enter the market and compete with 'Team Musk', we begin to transition from the monopolist's pricing model to some form of duopolistic competition. In this section, we will highlight the Cournot Model and illustrate how it could be integrated into this activity. As illustrated in Figure 3, Team Musk's reaction function to Team Bezos' output is and Team Bezos' reaction function to Team Musk's output is solving these equations we obtain an output of 4 for each firm (i.e., 4.22 rounded down to 4) and a price of $46 MM. Given the marginal cost of $36.7MM, industry profits are $74.4MM, and Team Musk's profits are $37.2MM; and Team Bezos' profits are $37.2MM.

Figure 3: Cournot Equilibrium



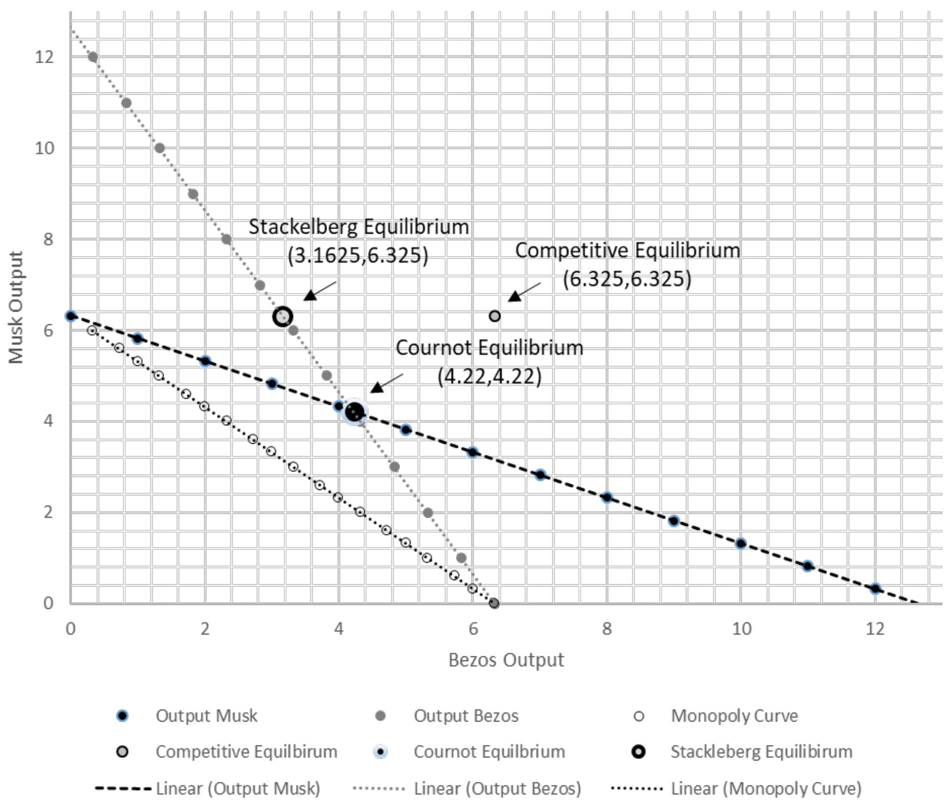
Note: This figure illustrates the relationship between the competitive equilibrium and the Cournot equilibrium.

Teaching Notes:

Stackelberg Duopoly

According to Huck, Muller, and Normann (2001), the underlying process by which a Stackelberg model of a duopoly reaches its equilibrium (i.e., a market leader sets output and a second firm produces output based on the leading firm's output) seems to better represent what may be occurring in duopolistic markets that have incumbent leaders, where research and development races occur, and in scenarios that sequential entry takes place (see Figure 4, which illustrates the Stackelberg Equilibrium). In an experiment comprised of individual participants, Huck, Muller, and Normann (2001) found that "under random matching, Stackelberg markets yield total quantities which are even higher than theoretically expected" (p. 750) and there is less collusion in a Stackelberg duopoly, and that leads to "higher consumer rents and higher welfare levels than Cournot markets" (p. 750). Cardella and Chiu (2012) suggested that to make a classroom experiment more realistic and create 'groups of individuals' that collectively made production decisions to represent Stackelberg firms. They find that group decision-making does not affect the decisions of the second group (i.e., the follower) in experimental settings, but it does affect the decisions that the first group makes, over repeated iterations of the game. Cardella and Chiu (2012) indicate that this learned behavior displayed by the first group seems to indicate, even though they produce less than the Stackelberg calculation would imply, that they anticipated their opponent's suboptimal response and maximized profits by reducing their output.

Figure 4: Stackelberg Equilibrium



Note: This figure illustrates the relationship between the competitive equilibrium, the Cournot equilibrium, the Stackelberg equilibrium, and the Monopolist's curve.

Teaching Notes:

Bertrand Competition

Given that we are using a constant cost schedule and operating under the assumption that these two competitors are selling a homogeneous product, we could introduce students to concepts related to the Bertrand Model. The model contends that if two firms that sell homogenous products compete, as long as we are assuming constant marginal costs, that marginal cost pricing is a unique Nash equilibrium (Baye & Morgan, 1999). The distinction that is made between the Cournot and Bertrand Models is that, according to Magnan de

Bornier (1992), under the assumptions of the Cournot Model, producers make their pricing decisions based on the output that their competitor produces; whereas, under the Bertrand Model, competitors make their decisions assuming that their competition will maintain their price, which creates conflict in terms of the optimal values associated with pricing and output decisions under these two regimes. The model is illustrated below and what it indicates is that if a firm *i* prices its product at price p_i as long as p_i is above marginal cost and below the price that the monopolist would charge, firm i would capture the demand in the industry (i.e., D_T) as long as its price is set below the competitor's price, which is denoted as p_j .

$$D_i(p_i, p_j) = \begin{cases} D_i|p_i \text{ } if \text{ } p_i < p_j, \text{ } Firm_i \text{ } captures \text{ } all \text{ } of \text{ } D_T \\ D_i = 1/_2 \, D_T \text{ } if \text{ } p_i = p_j \\ D_i|p_i \text{ } if \text{ } p_i > p_j, \text{ } Firm_i \text{ } captures \text{ } all \text{ } of \text{ } D_T \end{cases}$$

As a result of this, each firm competing in a Bertrand Duopoly, their reaction functions are as follows:

$$R_i(p_j) = \begin{cases} P^M & if \text{ } p_j > p^M \\ p_j - \varepsilon & if \text{ } c < p_j \leq p^M \\ c & if \text{ } p_j \leq c \end{cases}$$

Where is based on the price that firm *j* sells its product. If the price that firm *j* sells its product at is above the monopolist's price, then firm *i* will set its price to P^M (i.e., the monopolist's price). If firm *j* sets its price above the marginal cost, then firm i will set its price just below firm *j*'s price. Finally, if firm *j* sets its price below marginal cost firm *i*, it should produce at marginal cost. Note: that is a small discount to the price that the competitor charges. Figure 5 illustrates how the Bertrand model predicts that, according to Baye and Morgan (1999), "when two identical price-setting firms produce homogeneous products at constant marginal cost, marginal cost pricing is the unique Nash equilibrium" (p. 59). In other words, the two competitors will consistently underprice each other to a point that they reach a perfectly competitive outcome, because if one of the market participants does not follow this strategy and the other firm is not constrained, in terms of production, that firm will capture all of the quantity demanded in that market because it is selling at a lower cost.

Figure 5: Illustration of the Bertrand Duopoly

Note: This figure illustrates the relationship between Musk's and Bezo's reaction curves under the conditions of a Bertrand Duopoly.

4. Conclusion

This paper has illustrated how instructors could use a basic interaction between two competitors to teach concepts in economics such as cost, production, game theory, market structure, competition, and the factors of production. The paper also illustrates how teachers might modify our general framework to adapt the structure of this case to tailor it to their needs. What is intriguing about this example and what it adds to the literature on education in economics is how flexible it is and how adaptable this method could be using similar cases. The basic premise is that the characters that we use in this setting (i.e., Jeff Bezos and Elon Musk) may fade in terms of popularity and interest, but the basic structure that we have provided throughout this paper will enable teachers to swap these two personalities with the next two personalities that come along in the next emergent industry. We also believe that context is critical for students to engage in the study of economics, and this "do first" approach has many advantages over the traditional lecture or chalk and talk approach to economic education. Suggestions for future research would be to use an experimental framework to test whether incorporating the Musk versus Bezos exercise has an impact on learning by using a treatment and non-treatment grouping of classes.

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Appendix 1

Table 3: Activities

Activity Outline (Activities 1-3)				
Topic	**Course**	**Duration**	**Homework**	**Flipped Material**
Self-Interested Behavior	Principles of Microeconomics	30-Minute Discussion	Team Activity	Web Resources
Classroom discussion about how self-interested behavior leads to positive outcomes for society.	*(Integrate)*		*Team Musk and Bezos research their leaders' biography. Review the accompanying web resources.*	*The Invisible Hand - 60 Second Adventures in Economics:* https://www.youtube.com/watch?v=ulyVXa-u4wE
Demand Estimation	Principles of Microeconomics	20-Minute Activity 20-Minute Discussion	Team Activity	Web Resources
Provide teams with different point estimates associated with the demand curve (see Appendix II) and have them approximate the linear demand curve based on their knowledge of slope-intercept form. In groups, they should reflect on the group member's estimates and build the demand curve.	*(Estimate)*		*Review the accompanying web resources. Based on an assigned set of random points on the demand line for space flights, students should estimate the demand line.*	*The Demand Curve. Marginal Revolution University. URL:* https://youtu.be/kUPm2tMCbGE | *Demand and Supply Explained- Econ 2.1. Jacob Clifford - ACDC Economics. URL:* https://www.youtube.com/watch?v=LwLh6ax0zTE
Production Economics	Principles of Microeconomics	20-Minute Activity 20-Minute Discussion	Team Activity	Web Resources

In this activity, the students will vary one input of production, which is the number of space stations used. Groups of five or more students are provided a spacecraft (i.e., ball or some object that flies) and each student represents a space station. The students should determine what the optimal number of space stations would be to maximize efficiency.	*(Evaluate)*		*Review the accompanying web resources.*	*The Tennis Ball Games. Rutgers Today.* URL: https://youtu.be/J2RCg3ctZsA | *Total product, marginal product and average product | AP® Microeconomics. Khan Academy.* URL: https://youtu.be/8fm9FjDV0iA

Note: Table created by authors to illustrate topics related to (a) Self-Interested Behavior, (b) Demand Estimation, and (c) Production Economics.

Table 3: Activities (Continued)

Activity Outline (Activities 4-6)				
Topic	**Course**	**Duration**	**Homework**	**Flipped Material**
Market Equilibrium (Perfect Competition)	Principles of Microeconomics	20-Minute Activity 20-Minute Discussion	Team Activity	Web Resources
Race to the equilibrium price and quantity. After having the students watch the Marginal Revolution video have students compete in groups to reach the market equilibrium price and quantity.	*(Calculate)*		*Review the accompanying web resources. Be prepared to identify the equilibrium price and quantity that a perfectly competitive industry would produce.*	*The Equilibrium Price and Quantity. Alex Tabarrok (Marginal Revolution).URL:* https://mru.org/courses/principles-economics-microeconomics/equilibrium-price-supply-demand-example | *(Stop at 4 minutes) Does the Equilibrium Model Work? Alex Tabarrok (Marginal Revolution). URL:* https://youtu.be/1PP85wxHROg
Monopolist's Output and Price	Principles of Microeconomics	20-Minute Activity 20-Minute Discussion	Team Activity	Web Resources
Race to the monopolists' price and quantity. After having the student watch the Marginal Revolution video, have students compete in groups to reach the market equilibrium price and quantity.	*(Analyze)*		*Review the accompanying web resources.*	*Office Hours: Calculating Monopoly Profit. Mary Clare Peate (Marginal Revolution). URL:* https://youtu.be/FiQsdBWEaMI | Monopoly Graph Review and Practice- Micro 4.7. *Jacob Clifford (ACDC Economics)*. URL: https://www.youtube.com/watch?v=ZiuBWSFlfoU

Perfect Price Discrimination	Principles of Microeconomics	20-Minute Activity 20-Minute Discussion	Team Activity	Web Resources
In Appendix V, the directions for the activity are provided. Elon Musk tells you that you have conducted a blind auction for the space flights and provides you with price and quantity information (as well as names | assume no competitors). Use the concept of perfect price discrimination to maximize profits.	*(Explore)*		*Review the accompanying web resources.*	*Introduction to Price Discrimination. Tyler Cowen (Marginal Revolution). URL:* https://mru.org/courses/principles-economics-microeconomics/price-discrimination-examples-airlines-arbitrage | *Micro 4.8 Price Discriminating Monopoly (First Degree). Jacob Clifford (ACDC Economics). URL:* https://www.youtube.com/watch?v=s3wFJHluJPs

Note: Table created by authors to illustrate topics related to (a) Market Equilibrium (Perfect Competition), (b) Monopolist's Output and Price, and (c) Perfect Price Discrimination.

Table 3: Activities (Continued)

Activity Outline (Activities 7-8)				
Topic	**Course**	**Duration**	**Homework**	**Flipped Material**
Game Theory (Simultaneous and Sequential Play)	Principles of Microeconomics	20-Minute Activity 20-Minute Discussion	Team Activity	Web Resources
Group students into small teams, around four students each, and assign one group to represent Musk and one to represent Bezos. Both the simultaneous and sequential move games could be introduced at the beginning of class and four to five trials of blind simulation could be run under each condition. Over these trials, it is assumed that the majority of the groups will reach the Nash and Subgame Perfect Equilibrium.	*(Solve)*		*Review the accompanying web resources.*	*Oligopolies and Game Theory-Economies #8: The Dark Knight. Jacob Clifford (ACDC Economics).* https://www.youtube.com/watch?v=JMq059SAQXM *| D.8 Subgame equilibrium, Game Theory - Microeconomics. Policonomics. URL:* https://www.youtube.com/watch?v=8fCEfbx5ECE
Duopoly (Cournot, Stackelberg, & Bertrand)	Principles of Microeconomics Intermediate Price Theory	Undetermined	Team Activity	Web Resources

There are a number of ways that teachers could use these concepts to create an in-class activity. Since this is a situation in which we have a stable duopoly, students should be able to arrive at the Nash Equilibrium after blindly posting output decisions and then reflecting on how those output decisions affected their profits (Cournot) and then having the leading firm posting its output and determining how the second firm should respond over multiple interactions (Stackelberg). Finally, to test Bertrand students could determine prices and post over successive rounds and work their way back to the output for the duopoly to determine how efficient they when making pricing decisions.	*(Compare)*		*Review the accompanying web resources.*	Cournot. Alex Tabarrok (Marginal Revolution). URL: https://youtu.be/8r8IKmaqt08

Note: Table created by authors to illustrate topics related to (a) Game Theory (Simultaneous and Sequential Move Games) and (b) Duopoly (Cournot, Stackelberg, & Bertrand)

Appendix 2

Rubric

Criteria	Inadequate <13	Novice 13-14	Basic 15-16	Proficient 17-18	Exceptional 19-20
Self-Interested Behavior *(30%)*	Provides concrete theory inaccurately and not comprehensively	Provides theory accurately (mostly) but not comprehensively	Provides theory accurately but not comprehensively	Provides theory accurately (mostly) and comprehensively	Provides theory accurately and comprehensively
Identification of the Main Issues/Problems *(20%)*	Understanding is inaccurate and not comprehensive.	Understanding is accurate (mostly) but not comprehensive.	Understanding is accurate but not comprehensive.	Understanding is accurate (mostly) and comprehensive.	Understanding is accurate and comprehensive.
Recommendations *(40%)*	Recommendations are inaccurate and not comprehensive.	Recommendations accurate (mostly) but not comprehensive.	Recommendations are accurate, but not comprehensive.	Recommendations are accurate (mostly) and comprehensive.	Recommendations are accurate and comprehensive.
Organization, Word Choice, and Sentence Structure *(10%)*	Paper is disorganized, and information is not presented in a logical sequence. Grammar and word choice are not suitable for undergraduate-level work.	Paper is disorganized, and information is not presented in a logical sequence. Frequent grammatical errors and word choice needs improvement to be suitable for undergraduate-level work.	Paper is somewhat disorganized, and information is not presented in a logical sequence Frequent grammatical errors and word choice needs improvement to be suitable for undergraduate-level work.	Paper is organized, and information is presented in a logical sequence. Minimal grammatical errors and word choice meets expectations for undergraduate-level work.	Paper is organized, and information is presented in a logical sequence No grammatical errors, and word choice exceeds expectations for undergraduate-level work.

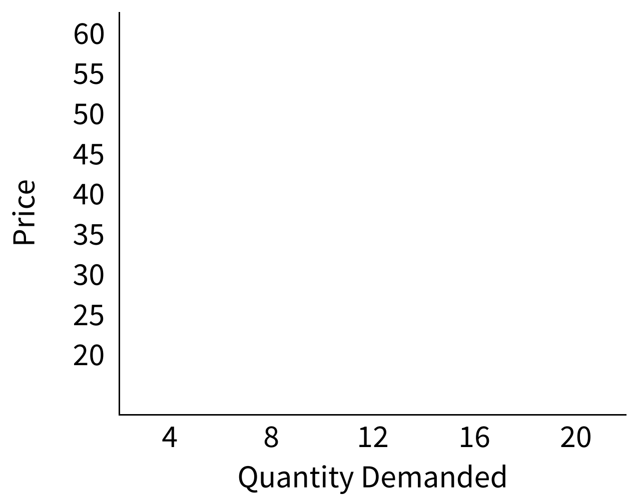
Appendix 3

Demand Estimation – Space Flights

Using four bids, plot the points and estimate the linear demand curve for Elon Musk's space flights.

Price	Bid # (Quantity Demanded)

Illustration of Demand for Space Flights



Follow-up Questions:

1. What is the relationship between price and quantity?

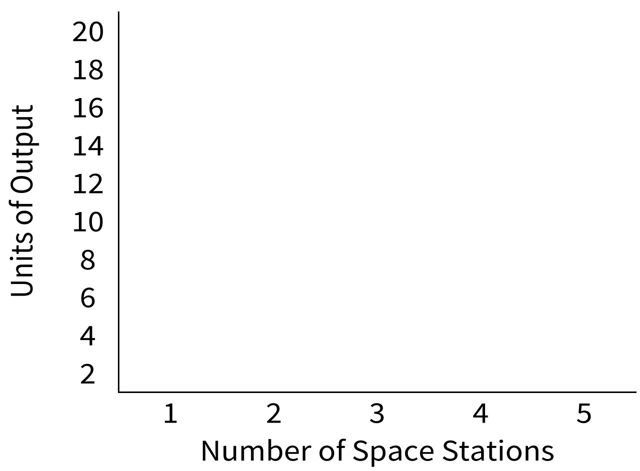
Appendix 4

Production Economics – Total and Marginal Product Calculation

Calculation of Total and Marginal Product

Space Station(s)	Total Output	Marginal Output (i.e. ΔQ / ΔL)
0		
1		
2		
3		
4		
5		

Illustration of Total and Marginal Product



Follow-up Questions:

1. Over what range of space stations do we observe increasing marginal productivity?

2. Over what range of space stations do we observe diminishing marginal productivity?

3. Over what range of space stations do we observe negative marginal productivity?

Appendix 5

Competitive Equilibrium

Output	Price	Total Revenue	Total Cost	Marginal Cost	Profit
0	-	-		-	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

1. At What Point Does this Market Approach the Competitive Equilibrium?

2. What are profits equal to at this point?

Appendix 6

Monopoly Profit Maximization

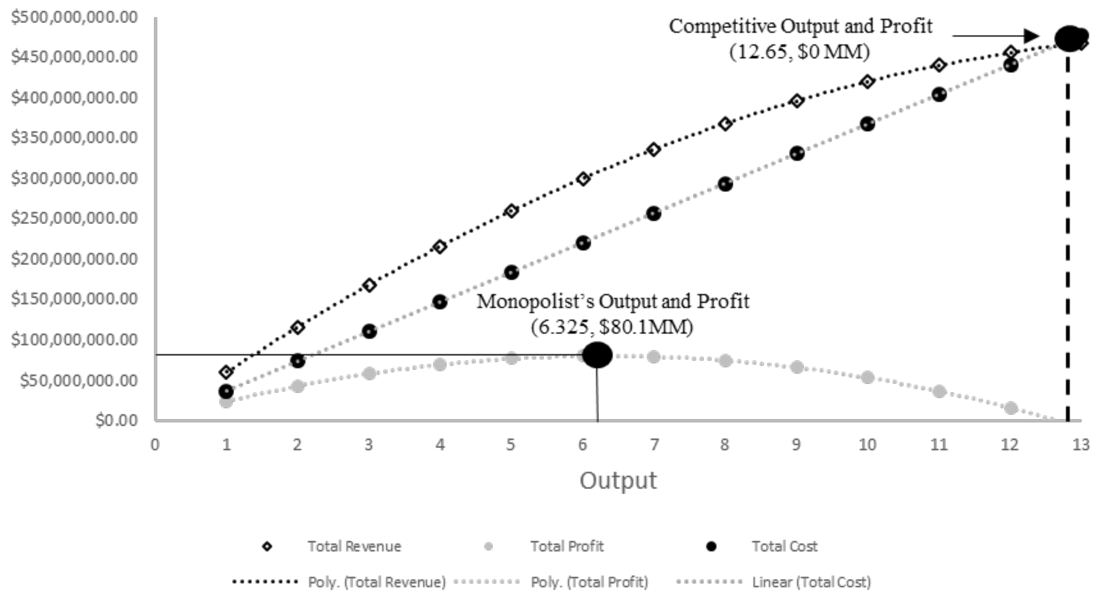
Output	Price	Total Revenue	Marginal Revenue	Total Cost	Marginal Cost	Profit
0	-	-	-	-		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						

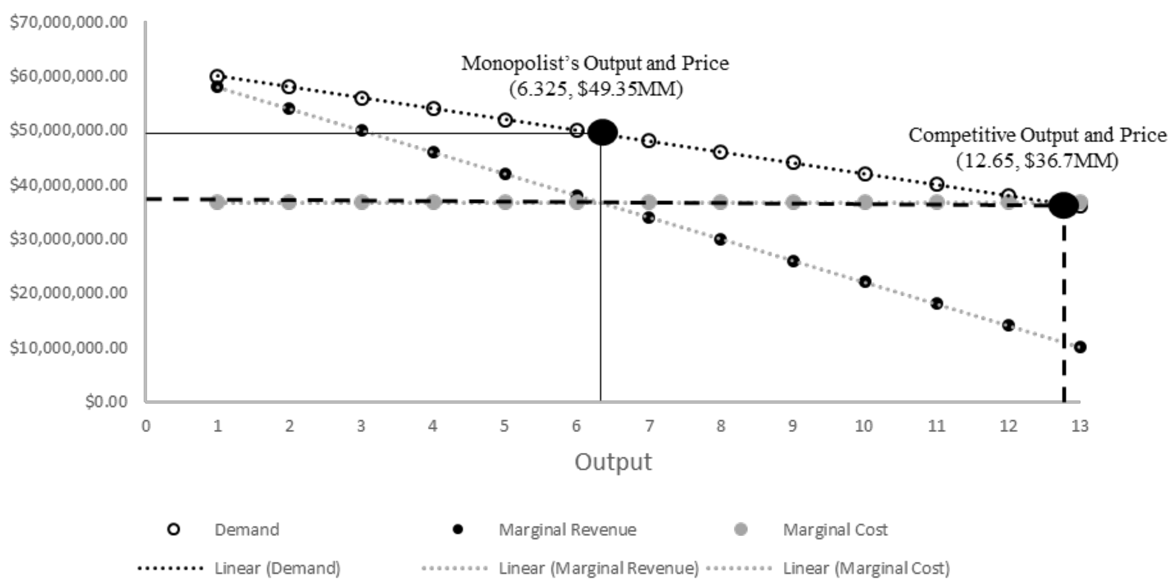
1. At What Point Does this Monopolist Maximize Profits?

2. What are profits equal to at this point?

Appendix 7

The Monopolist & Competitive Equilibrium





Appendix 8

Monopoly Calculations

$$TR_{Musk} = P * Q_{Musk}$$
$$TR_{Musk} = (\$62MM - \$2MMQ_{Musk}) * Q_{Musk}$$
$$TR_{Musk} = \$62MMQ_{Musk} - \$2MMQ_{Musk}{}^{2}$$
$$MR_{Musk} = \frac{\Delta TR}{\Delta Q_{Musk}} = \$62MM - \$4MMQ_{Musk}$$
$$\pi_{Max} \rightarrow MR_{Musk} = MC_{Musk}$$
$$\$62MM - \$4MMQ_{Musk} = \$36.7MM \rightarrow Q_{Musk} = 6.325$$
$$P_{Musk} = \$62MM - \$2MM(6.325) \rightarrow \$62MM - \$12.65MM \rightarrow \$49.35MM$$
$$TR_{Musk} = P * Q_{Musk} \rightarrow \$49.35MM * 6.325 \rightarrow \$312.14MM$$
$$TC_{Musk} = MC * Q_{Musk} \rightarrow \$36.7MM * 6.325 \rightarrow \$232.13MM$$
$$\pi_{Musk} = TR_{Musk} - TC_{Musk} \rightarrow \$312.14MM - 232.13MM \rightarrow \$80.01MM$$

Appendix 9

Perfect Price Discrimination

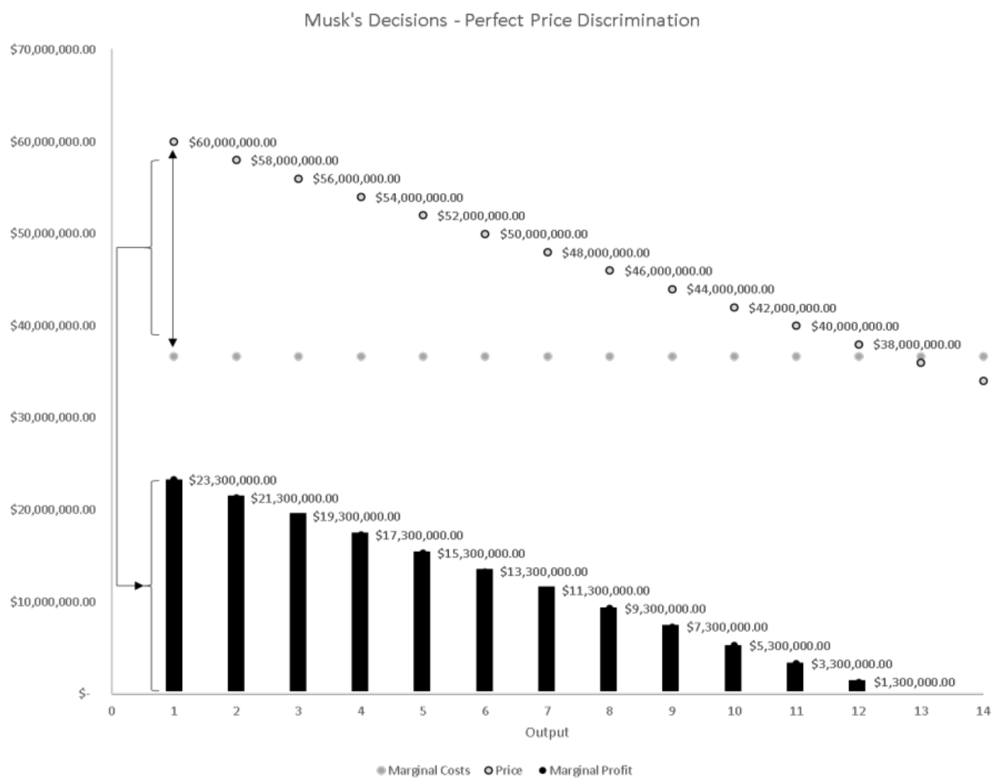
Consider what would happen if Musk engaged in perfect price discrimination (Note: to accomplish this calculate the profits that Musk would be able to extract if he was able to transfer all consumer surplus to producer surplus). The following worksheet should give you a starting point.

Output	Price	Marginal Revenue	Marginal Cost	Marginal Profit
0	-	-	-	-
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

1. Under conditions of perfect price discrimination, how much consumer surplus is Musk able to extract?

2. Thinking back to how we typically describe consumer surplus, how different is this to our ‘estimate’ of consumer surplus (e.g., obtained using 1/2 * base * height)?

3. How would you explain this difference? Discuss.



Appendix 10

Game Theory – Incentives to Cheat

Assuming that Jeff Bezos of Blue Origin wants to enter the market in the second year, how does his entry affect SpaceX's profitability and Elon Musk's decisions? Why don't Musk and Bezos simply act like monopolists and split production?

Musk 4 and Bezos 4

Price: ____________________

Marginal Cost: ____________________

$\text{Profit}_{\text{Musk}}$ ____________________

$\text{Profit}_{\text{Bezos}}$ ____________________

$\text{Profit}_{\text{Industry}}$ ____________________

Musk 4 and Bezos 3

Price: ____________________

Marginal Cost: ____________________

$\text{Profit}_{\text{Musk}}$ ____________________

$\text{Profit}_{\text{Bezos}}$ ____________________

$\text{Profit}_{\text{Industry}}$ ____________________

Musk 3 and Bezos 4

Price: ____________________

Marginal Cost: ____________________

$\text{Profit}_{\text{Musk}}$ ____________________

$\text{Profit}_{\text{Bezos}}$ ____________________

$\text{Profit}_{\text{Industry}}$ ____________________

Musk 3 and Bezos 3

Price: ____________________

Marginal Cost: ____________________

$\text{Profit}_{\text{Musk}}$ ____________________

$\text{Profit}_{\text{Bezos}}$ ____________________

$\text{Profit}_{\text{Industry}}$ ____________________

Appendix 11

Cournot Duopoly Calculations

Cournot Reaction Functions

$P_{Industry} = \$62MM - \$2MMQ_{Industry}$
$Q_{Industry} = Q_{Musk} + Q_{Bezos}$
$TR_{Musk} = P_{Industry} * Q_{Musk}$
$TR_{Musk} = [\$62MM - \$2MM(Q_{Musk} + Q_{Bezos})] * Q_{Musk}$
$TR_{Musk} = [\$62MM - \$2MMQ_{Musk} - \$2MMQ_{Bezos})] * Q_{Musk}$
$TR_{Musk} = \$62MMQ_{Musk} - \$2MMQ_{Musk}{}^2 - \$2MMQ_{Musk}Q_{Bezos}$
$MR_{Musk} = \frac{\Delta TR_{Musk}}{\Delta Q_{Musk}} = \$62MM - \$4MMQ_{Musk} - \$2MMQ_{Bezos}$
$MR_{Musk} = MC_{Musk} \rightarrow \$62MM - \$4MMQ_{Musk} - \$2MMQ_{Bezos} = \$36.7MM \rightarrow Q_{Musk} = \$6.325MM - 0.5MM * Q_{Bezos}$

Cournot Reaction Functions

Team Musk: $Q_{Musk} = \$6.325MM - 0.5MM * Q_{Bezos}$
Team Bezos: $Q_{Bezos} = \$6.325MM - 0.5MM * Q_{Musk}$

Cournot Output & Profitability

$Q_{Musk} = \$6.325MM - 0.5MM * (\$6.325MM - 0.5MM * Q_{Musk}) \rightarrow Q_{Musk} = \$6.325MM - \$3.1625MM + 0.25MMQ_{Musk} \rightarrow Q_{Musk} = 4.22$
$TR_{Musk} = P_{Industry} * Q_{Musk} \rightarrow \$45.12 * 4.22 \rightarrow \$190.41$
$TC_{Musk} = MC_{Musk} * Q_{Musk} \rightarrow \$36.7 * 4.22 \rightarrow \$154.87$
$\pi_{Musk} = TR_{Musk} - TC_{Musk} = \$190.41MM - \$154.87MM = \$35.54MM$
$Q_{Bezos} = \$6.325MM - 0.5MM * (\$6.325MM - 0.5MM * Q_{Bezos}) \rightarrow Q_{Bezos} = \$6.325MM - \$3.1625MM + 0.25MMQ_{Bezos} \rightarrow Q_{Bezos} = 4.22$
$TR_{Bezos} = P_{Industry} * Q_{Bezos} \rightarrow \$45.12 * 4.22 \rightarrow \$190.41$
$TC_{Bezos} = MC_{Bezos} * Q_{Bezos} \rightarrow \$36.7 * 4.22 \rightarrow \$154.87$
$\pi_{Bezos} = TR_{Bezos} - TC_{Bezos} = \$190.41MM - \$154.87MM = \$35.54MM$

Appendix 12:

Stackelberg Duopoly Calculations

$$TR_{Musk} = \$62MMQ_{Musk} - \$2MMQ_{Musk}{}^2 - \$2MMQ_{Musk}Q_{Bezos}$$
$$TR_{Musk} = \$62MMQ_{Musk} - \$2MMQ_{Musk}{}^2 - \$2MMQ_{Musk}(\$6.325MM - 0.5 * Q_{Musk})$$
$$TR_{Musk} = \$62MMQ_{Musk} - \$2MMQ_{Musk}{}^2 - \$12.65MMQ_{Musk} + Q_{Musk}{}^2$$
$$TR_{Musk} = \$49.35MMQ_{Musk} - Q_{Musk}{}^2$$
$$MR_{Musk} = \frac{\Delta TR_{Musk}}{\Delta Q_{Musk}} = \$49.35MM - \$2MMQ_{Musk}$$
$$MR_{Musk} = MC_{Musk} \rightarrow \$49.35MM - 2MMQ_{Musk} = \$36.7MM \rightarrow Q_{Musk} = 6.325$$
$$Q_{Bezos} = \$6.325MM - 0.5MM * Q_{Musk} \rightarrow 3.1625$$
$$Q_{Total} = Q_{Bezos} + Q_{Musk} \rightarrow 6.325 + 3.1625 \rightarrow 9.4875$$
$$P_{Industry} = \$62MM - \$2MMQ_T \rightarrow \$43.025$$
$$\pi_{Unit} = \$43.025MM - \$36.7MM \rightarrow \$6.325$$
$$\pi_{Musk} = \pi_{Unit} * Q_{Musk} \rightarrow \$40.01MM$$
$$\pi_{Bezos} = \pi_{Unit} * Q_{Bezos} \rightarrow \$20M$$