

USING GAME THEORY TO TEACH PRINCIPLES OF MICROECONOMICS

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Abstract

The use of game theory to illustrate decision-making and competition in oligopolistic industries has become commonplace in economics. However, little attention has been focused on using game theory to teach other areas of economic theory. For example, game theory can be used to teach the economic principles of marginal analysis and opportunity cost, utility maximization, supply and demand analysis, and industry analysis. This paper provides a case study demonstrating how game theory can be used to teach an entire introductory microeconomics course. While one can certainly adapt the mathematical rigor of game theory to meet virtually any educational level, we believe that principles courses are most in need of a new paradigm since this is where most students receive their first (and often their only) exposure to economics.

Introduction

Recently, the empirical literature in economics has identified a disturbing trend: (1) economic literacy in the U.S. is very low, and (2) principles of economics courses have only a marginal, if any, impact on economic literacy. For example, Walstad and Rebeck (2002) found that students completing a high school or college economics course had very low levels of economic literacy. Additionally, Walstad and Algood (1999) found that while college seniors who completed an economics course did have higher levels of economic literacy than those completing a high school economics course or those who have never completed an economics course, the difference was marginal at best. Given that approximately 40 percent of all college students take at least one economics course, this implies that introductory economics courses are not only failing to fulfill their mission but that a significant number of students are affected by this failure (Siegfried 2000).

In response, economic educators have posited new approaches to improve both the appeal and effectiveness of introductory economics courses. One common theme in the economic education literature is to change the way in which economics is taught, that is, a change in pedagogy. Becker (2001), for instance, advocates a reduction in the traditional “chalk and talk” method in favor of an “active learning” approach. Other studies, including Salemi et al. (2001) and Siegfried and Sanderson (2003), agree with Becker. However, Siegfried and Sanderson also note that factors such as student-to-teacher ratios, course levels (i.e., advanced undergraduate versus introductory-level courses), and faculty positions with more stringent research expectations may limit the feasibility of this approach. They are also careful to note that the chalk and talk method may actually be a component of a successful active learning approach.

Another approach, also postulated by Becker (2001) and commented on by Siegfried and Sanderson (2003), is to add “really cool stuff” to supplement course content.¹ Essentially, this entails incorporating real world examples into lectures, homework, and other course material to make economic tools and concepts more “applicable to reality” in the eyes of students.

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¹ Becker (2001) also postulates another approach, which is for administrators to change compensation in a way that causes instructors to give a higher level of effort in the classroom.

A third approach is to change the *tools and concepts* that are taught in economics courses. One example, espoused by the National Council on Economic Education particularly for high school and introductory college-level instructors, is to reduce course content to a set of 20 important tools and concepts, which are defined as the “Voluntary National Content Standards in Economics” (NCEE 1997). This allows instructors more time and flexibility to cover these core concepts, thereby enhancing student retention, in addition to adding the “really cool stuff” advocated by Becker.²

A potential drawback to each of these approaches is that principles of economics courses embody an increasingly wide range of students, each with different educational needs (Salemi and Siegfried 1999). Introductory economics courses, in particular, satisfy the needs of three different groups of students: (1) students who need an economics course to satisfy the general education requirements for a college degree, (2) business students who need a basic understanding of economics for future coursework in related disciplines, and (3) students intending to major in economics. The first group of students needs a more general understanding of economics than the latter two groups. Thus, the approaches espoused by both Professor Becker and the NCEE may be effective ways to teach introductory economics to the first group of students. However, economics and business majors need a more thorough understanding of economics as they will take a number of subsequent economics and/or business courses, most of which employ a traditional approach to convey the subject matter. Given budget and accreditation constraints which do not allow for multiple principles of economics course offerings, a new paradigm for effectively teaching economics must also be flexible enough to simultaneously meet the diverse demands of students taking the course.

In this paper, we argue that there is a common thread linking these paradigms to a traditional introductory microeconomics course—the use of game theory.³ If this link exists, then it may be possible to change how instructors teach principles of microeconomics courses (in a manner consistent with those espoused by both Becker and the NCEE) to ensure that students successfully completing these courses significantly increase their understanding of economics.

The remainder of this paper proceeds in three steps. First, we briefly describe why game theory represents a viable paradigm to convey economic content in an effective and efficacious manner. Next, we provide some examples to illustrate the numerous pedagogical uses of game theory. We focus our efforts on microeconomic concepts that are not traditionally taught (at the principles level) using game theory, including the concepts of opportunity costs and marginal analysis, utility maximization, supply/demand analysis, and industry analysis. We conclude the paper by summarizing our findings and presenting some suggestions for future work in this area.

Game Theory as a Comprehensive Microeconomic Pedagogical Device

Several factors make game theory a useful, comprehensive tool for teaching principles of microeconomics. First, game theory is generally accepted as a standard microeconomic tool. Therefore, most instructors should be familiar with (and comfortable teaching) basic game theory. Virtually all principles of economics textbooks devote some space to game theory, usually in the

² Hansen et al. (2002) take these standards and go further by providing specific recommendations about what content should be cut from introductory courses. In principles of microeconomics courses, they advocate limiting the use of graphs and elasticities, eliminating the discussion of cost curves and eliminating comparisons of different types of imperfectly competitive markets.

³ It may also be the case that game theory represents this link in introductory macroeconomics courses. However, we choose to focus on microeconomics because game theory is generally taught in the oligopoly sections of this course. Therefore, using game theory to teach an *entire* micro principles course is both easier to establish and more intuitive to academic economists. We leave establishing this link for principles of macroeconomics as a suggestion for future research.

chapters covering oligopoly theory (for example, see McEachern 2006; Frank and Bernanke 2006; Colander 2004; McConnell and Brue 2005). However, a handful of introductory economics textbooks apply game theory to other topics, including information theory (Frank and Bernanke 2006).

Second, game theory can be applied to virtually any economic problem in a manner that is accessible to students of different mathematical backgrounds and levels of exposure to economics. As an empirical illustration, one need only look at the variety of different economics textbooks currently available that focus exclusively on game theory. Each of these textbooks covers a broad range of economics topics—not just oligopoly theory. Mas-Colell, Whinston and Green (1995), Myerson (2001), and Fudenberg and Tirole (1991) are examples of Ph.D.-level economics textbooks utilizing game theory. At the masters or advanced undergraduate level, examples include Rasmussen (1989), Bierman and Fernandez (1993), and Gardener (2003). At a less technical level (one that requires only basic algebra), examples include McCain (2004) and Dixit and Skeath (2004). Not only do these same textbooks incorporate mathematics at different levels, but they also cater to students with broad ranges of exposure to economics. In particular, introductory texts that are less focused on mathematics and more focused on interdependent economic decision-making can be used to teach courses to students with no prior knowledge of economics. To a lesser extent, more technically advanced game theory texts can efficaciously convey economic concepts to students familiar with mathematics but unfamiliar with economics.

Third, game theory can be used to teach economics to a broad range of students. For students taking introductory economics courses to satisfy general education requirements, game theory can be used as an interdisciplinary approach to teaching economics. The Dixit and Skeath (2004) text does exactly this—it uses game theory to blend ideas from economics with other disciplines, including sociology, political science, biology, and history.⁴ For economics students who need a thorough understanding of the tools, not only as they should be taught but also as they are taught, game theory can be used as a pedagogical tool to teach the basic ideas and concepts first. In turn, students more thoroughly and critically understand the economic concept, should the instructor also choose to present that same concept in its traditional construct.

Fourth, game theory is an effective tool for teaching economics to business students as background for future coursework in their subdisciplines (i.e., marketing, operations, or management). Each of these business fields places a high level of emphasis on the creation and implementation of *strategic decision-making*—the fundamental concept of game theory. Additionally, creating strategy is based not only on the technical aspects of strategy, such as SWOT analysis and business planning, but also on the potential ethical and cultural ramifications of taking a particular action (Besanko et al. 2004). While this certainly requires an understanding of economics, it also requires students to think critically about how the assumptions behind an economic model influence that model's outcome. That is, game theory forces students to think about how economic concepts and tools are fundamentally tied to other, related disciplines.

Perhaps the most important attribute of game theory is that it is grounded in the *case study method of teaching*. When using game theory to make decisions, one must first “set up the game.” The setup of the game is primarily determined by the assumptions underlying that “case.” More specifically, assumptions about history, culture, and human behavior play a crucial role in determining the structure of a game as well as the relative magnitude of the game's payoffs, which in turn determine what actions players take. In essence, the case study approach explicitly requires

⁴ The Dixit and Skeath book is actually based upon a general-education survey of economic ideas course taught by Professor Dixit at Princeton. This course is geared toward first-year students with no prior knowledge of economics and no mathematics requirements other than college-level algebra. The course does not, however, take the place of traditional principles of economics courses. The premise of our paper is simply that one could use game theory to teach a principles of microeconomics course.

the instructor to add “really cool stuff” to course content, because the setup of the game provides a more realistic and relevant context to the tools being studied.

Some Pedagogical Illustrations

Background

Successfully using game theory as a pedagogical tool for teaching introductory microeconomics necessitates that the course focus on problem solving.⁵ Problem solving should not only permeate lectures, but students should also be given the opportunity to complete homework assignments containing similar problems allowing them to immediately apply the concepts and tools taught in the lecture. In either case, the initial information is conveyed as a story problem describing some social situation that is interesting and relevant to students. Students are then required to use basic game theory to develop and solve an economic model depicting potential outcomes of the decision problem. Students should also be asked to explicitly state the assumptions underlying each and every model and to identify how each assumption shapes the outcome of the game. As a result, students are forced to apply critical thinking skills using quantitative reasoning in order to relate the context of the case to the economic decision outcome(s) produced by the game.

The role of the instructor in this method of teaching is to ensure that students have developed a complete list of assumptions and to emphasize that each assumption incorporates information about individual and/or social objectives in addition to tastes and preferences. Values are not independent of decision-making. Maybe most important is to illustrate that when assumptions are altered, more often than not so are conclusions. Once a problem is solved, the instructor should subsequently ask students to make recommendations based on the model. That is, when faced with this information, what is a “good choice” to make? A discussion of what defines a “good choice” allows the instructor to illustrate the economic principle(s) underlying the decision problem. The instructor should also illustrate the connection between assumptions and decision-making by altering the assumptions underlying the story problem and asking students to determine whether relaxing those assumptions alters the game’s solution. In essence, students are performing a sensitivity (or comparative static) analysis to deduce how altering the assumptions of the model (which are essentially held constant) impact decision-making.

In what follows, we provide some examples of how game theory can be used to motivate economic concepts traditionally taught in an introductory microeconomics course. To be consistent with our previous discussion, we focus on using game theory to teach economic concepts that are not only espoused by the NCEE and the related literature but are also not traditionally taught (at the principles level) using game theory. In these examples, we also assume that the reader is familiar with the basic tenants of game theory. We refer the reader to Dixit and Skeath (2004) or Gardener (2003) if this is not the case.

A Simple Game Designed to Teach the Concepts of Rational Decision-Making, Marginal Analysis, and Opportunity Costs⁶

Josh Davis is a first-year law school student and has found law school to be quite a change from his undergraduate program because his entire grade in any given course is based solely on his performance on the final exam. Knowing his strengths and weaknesses, Josh is sure that he cannot cram for an exam. Instead, he decides to set up a schedule with a constant allocation of time between studying and other activities. Unfortunately, law school is also expensive; to pay for

⁵ At a more advanced level of instruction, game theory can also be conveyed through the analyses of case studies, which are essentially more detailed story problems.

⁶ This example takes its genesis from Frank and Bernanke (2006).

school Josh works as a tutor at the university’s Writing Center. It only pays the minimum wage, but jobs around the university are scarce, and this position allows him the flexibility to set the number of hours he works each week.

On the first day of classes, each of his professors distributes a course syllabus and explains that the final exam will be graded on a curve. As a result, performance on the final exam will be measured relative to the other students in the class. If Josh outperforms most of his peers, he will earn a “good” grade. If he studies about the same amount, he will get an “average” grade, and if he doesn’t study much, he is sure that he will fail the course.

Josh considers himself about average relative to his peers. As a result, good grades will give him a strong sense of accomplishment and bolster his grade point average. However, Josh knows it will take a lot of studying to perform well in the course. On a 0 to 10 scale, Josh rates receiving an A in any course as a 10, an average grade as a 5, and a failing grade as a 0. On the other hand, the costs (in terms of lost wages and free time) of studying on the same 0-to-10 scale are 4 for studying a little and 7 for studying a lot. Finally, since Josh considers himself near the average of his law school class (all of whom are taking the same set of courses), he assumes that the rest of the class (at least on average) faces a similar set of decisions and has similar costs and benefits. If Josh’s assumptions are correct and if Josh makes his decision without observing the choice of his classmates (and vice versa), how much should he study per week: a lot or a little?

Analysis

The case in normal form is set up as follows:

		The “Average” Person in the Class	
		Study a Little	Study a Lot
Josh	Study a Little	(1; 1)	(-4; 3)
	Study a Lot	(3; -4)	(-2; -2)

There is a single pure strategy Nash equilibrium where everyone studies a lot and the payoffs are average grades with a lot of work, yielding net benefits of -2 for everyone.

This simple example allows instructors to illustrate several key economic concepts. For example, the concept of rational decision-making can be conveyed by defining the alternatives of each of the decision-makers as well as through the use of net benefit calculations as payoffs. The process of determining the Nash Equilibrium also requires students to evaluate opportunity costs and utilize marginal analysis. As an example, consider the scenario where the “average” person in the class studies a little, Josh must choose the option with the highest marginal benefit, which in this case is to study a lot, since the marginal net benefit of this alternative is 2 (or 3-1). But, by definition, marginal analysis also incorporates opportunity cost. In this scenario the opportunity cost of studying a lot is the net benefit of studying a little, which is 1.

Using a game theoretic approach to present and discuss rational, marginal analysis has several advantages over the traditional approach. First, to find the Nash Equilibrium, students must evaluate several scenarios and complete several marginal analyses. This forces students to calculate opportunity costs and apply marginal analysis several times before arriving at a solution, which necessarily increases the likelihood that students understand and master the concept. Additionally, in each scenario the opportunity costs and net benefits change. That is, even though Josh has a “dominant strategy” to study a lot (i.e., there is a positive marginal net benefit to

studying a lot regardless of what the other students do), the magnitude of this marginal net benefit changes across scenarios. This underscores a central tenant of economics, namely that opportunity costs are subjective and vary by time the decision being made and the characteristics of the decision-maker.

Perhaps the greatest benefit is that instructors can use the setup of the game to actively involve students in the decision-making process to determine whether, indeed, a “good” choice was made. As an example, the instructor might choose to introduce the problem (inclusive of the benefits and costs) to the class. But before actually solving the problem via game theory, the instructor might ask the class, through a formal written vote, an open class discussion, or a combination of the two, what they expect the outcome to be and what their rationale for that conclusion was. In essence, an experiment is conducted to test whether the students in the course are implicitly using rational behavior. Some will not vote for the rational decision, which then gives the instructor an opportunity to teach students what role the rationality assumption plays in economics and how it shapes outcomes.

For instructors wishing to demonstrate the impact that values, risk tendencies, and other characteristics have on decision-making, one can conduct this same process *without* explicitly providing the numerical costs. Once a general class discussion of the potential outcomes has been completed, it is then possible to show with different sets of numerical costs and benefits (which implicitly characterize the decision-maker’s values) how a variety of different “optimal” decisions can be made, depending on the values of the decision-maker. In essence, the instructor has walked the students through a rudimentary sensitivity (or comparative static) analysis. One example is to reduce the costs of studying a little to 1. In this case, the Nash equilibrium is for everyone to study a little. Another possibility is to assume that the “average” person in the class has a different set of benefits and costs than does Josh.

An Example to Illustrate Comparative Advantage and Specialization

Atlantia is a large island in a remote part of the South Pacific. While all of the island’s inhabitants are culturally similar, the island is divided both politically and geographically. There are two distinct countries (East Mojo and West Mojo) on the island, each of which covers about half of the island. East Mojo’s landscape is very similar to that of California in that it has low lying mountains and a Mediterranean climate, while West Mojo’s landscape and climate are more like Kansas, consisting mostly of rolling plains and open grassland. Despite geographic and political differences, the inhabitants share a common culture, including dietary preferences. Most Atlantians prefer to drink wine and eat pasta.

In any given month, East Mojo’s inhabitants currently produce and consume 36,000 pounds of pasta and 4,000 flasks of wine, while West Mojoans produce and consume 16,000 pounds of pasta and 2,000 flasks of wine. If East Mojo devoted all of its resources to producing only one good, it could produce either 60,000 pounds of pasta or 10,000 flasks of wine. Similarly, if West Mojo produced only one good, it could produce either 24,000 pounds of pasta or 6,000 flasks of wine.

In order to stimulate economic growth, both countries’ governments are currently negotiating a trade agreement. Under the terms of this agreement, each country would specialize in the production of a particular good. If one or both of the countries fail to adopt the agreement, they maintain the status quo, and each country produces an amount of both wine and pasta that is sufficient to meet its citizens’ current consumption. If both countries adopt the agreement and decide to produce the same good, then no trade takes place, since each country can produce enough of the good to cover domestic consumption and since there is nothing new to trade for in the other country. However, if both countries produce different goods, then after satisfying consumption in the home country, they can trade any excess production at current market prices to the other country. Assume the current market price for pasta is one gold coin per pound and the

price of wine is five gold coins per flask. Would each country agree to trade, and if so, which good would each country produce? Assume for simplicity that decisions are made simultaneously and that a country's welfare can accurately be measured using the monetary value of total production consumed in the country.

Analysis

The normal form of the game is presented below, where all payoffs are measured in gold coins. For simplicity, we have assumed that there are three alternatives facing each country: do not adopt the agreement and keep the status quo, adopt the agreement and produce pasta, or adopt the agreement and produce wine.

		West Mojo		
		Keep Status Quo	Produce Only Pasta	Produce Only Wine
	Keep the Status Quo	(56,000; 26,000)	(56,000; 24,000)	(56,000; 30,000)
East Mojo	Produce only Pasta	(60,000; 26,000)	(60,000; 24,000)	(64,000; 26,000)
	Produce only Wine	(50,000; 26,000)	(48,000; 26,000)	(50,000; 30,000)

There is a single pure strategy Nash equilibrium where both countries agree to specialize and trade. East Mojo specializes in pasta production while West Mojo specializes in wine production. The payoffs are 64,000 gold coins for East Mojo and 26,000 for West Mojo. Additionally, under this scenario not only do both countries satisfy current consumption but East Mojo gains 8,000 additional pounds of pasta.

As with the previous example, characterizing a simple trading problem in game theory format can also be a vehicle for discussing comparative and absolute advantage. Clearly, the higher payoffs for East Mojo over all possible courses of action demonstrate that it is better at producing both types of goods and thus has an absolute advantage in the production of both goods. The Nash equilibrium of the game can also be used as a vehicle for motivating the logic behind the concept of comparative advantage. Both countries specialize and trade because each country has a dominant strategy to specialize in the production of a single good. The question instructors should pose to students is *why* each country has a dominant strategy to produce a particular good. This, in turn, allows the instructor to demonstrate (possibly by using traditional opportunity cost calculations) the impact that opportunity cost calculations have in determining efficient production and, hence, the law of comparative advantage. The fact that firms specialize and produce a good for which they have a comparative advantage allows them to capture these efficiency gains, which naturally leads to the dominant strategies discussed above.

Another attribute of game theory is that it allows instructors to effectively illustrate and address several issues that may (at first) appear counterintuitive to students. The first is that, in order to gain efficiency and act upon one's comparative advantage, countries, economies and/or firms may be forced to specialize in goods they may not have developed a reputation for producing. For example, one would not expect a country whose landscape and climate resembles California to cease wine production and specialize in the production of products like pasta. Similarly, one might not expect a country resembling Kansas to stop producing wheat/pasta and instead produce wine.

A second, potentially counterintuitive finding clearly depicted by game theory is why West Mojo would even agree to specialize and trade at all. In many comparative-advantage examples, specialization and trade allow both trading partners to be made better off. But this is not always the case. In our example, there are clear benefits to specialization and trade on aggregate; however, they are all captured by one country. In such cases, the law of comparative advantage does not effectively demonstrate why West Mojo would agree to trade, since it gains nothing from doing so. However, depicting this decision process as a game highlights the logic behind this idea. To illustrate this concept, the instructor can randomly pick any point (other than the Nash equilibrium) as a starting point for the analysis. Then, by comparing potential payoffs across alternatives, one can see how one country's pursuit of higher payoffs forces the other country (who may not directly benefit from specialization and trade) to react by specializing and trading, thereby leading to the efficient outcome. For example, suppose both countries start at the status quo. Then West Mojo has an incentive to switch solely to wine production because it increases its payoff from 26,000 to 30,000. At the same time, this also provides East Mojo with an incentive to specialize, because this increases their payoff from 56,000 to 60,000. But, perhaps more important, East Mojo's gain from specialization comes at the expense of West Mojo, whose payoffs at the Nash equilibrium drop from 30,000 back to 26,000.

A third and final benefit of using game theory to discuss comparative advantage is that it allows the instructor an additional tool to perform sensitivity analyses, where changes in the assumptions of the model affect both the decision to specialize and trade and the gains from such trade, if it occurs. One example is to change the market price for each good and see whether and how those changes impact (1) whether trade occurs and (2) if trade does occur, who gains (and how much is gained) from specialization. Another possibility is to change the production possibilities for each country, which in turn changes each country's comparative advantage and, hence, optimal decisions. By repeatedly working through small variations in the original game, students gain a stronger understanding of the logic underlying comparative advantage as well as how cultural and market forces impact that advantage.

An Example to Illustrate Utility Maximization, Profit Maximization, and Market Equilibrium

Holly is a typical college student living in Chico, California. She attends classes during the day and works as a waitress at the local vegetarian restaurant in the evenings. The pay is good, but tuition, room, and board are expensive; after paying all of her other bills, she only has about \$200 per month to allocate between clothes and recreation. Holly's favorite pastime is going to the movie theatre. After paying for her ticket and a small serving of popcorn, it usually costs her about \$12 to see a movie.

In Chico, it's still popular to be a Grateful Dead fan, and Angie's Ty-Dy Shop is the best place in town to buy the band's official line of clothing. After looking through her closet, Holly decides that she needs to buy a few more shirts. In order to keep prices reasonable for their fans, the band requires that all stores charge the same price for their products. After checking out prices on the band's website, Holly finds that her style of shirt costs \$8 each. The real question for Holly is how many shirts to buy? With such reasonable prices, she can afford to buy more than one, but the Ty-Dy's selection and availability may limit her choices.

On the other hand, Angie really enjoys carrying the Dead's clothing line, but her livelihood depends on the store turning a profit. With fixed prices, inventory control is crucial to maintaining profitability. While Angie strives to meet her customers' needs (and she believes that Holly is a pretty typical customer), she also does not want to hold inventory that doesn't sell, because that drives up her costs.

Suppose that the following normal form game represents the decision process faced by Holly and Angie. Each has an option to buy and/or sell four, six, or eight shirts. Holly's payoffs

represent her net benefits (measured in numerical form) from buying a particular quantity of shirts, while Angie’s payoffs represent her net monetary gain from selling a particular quantity of shirts. Based on this information, how many shirts should Holly buy, and how many shirts should Angie sell?

		Angie		
		Sell 4 Shirts	Sell 6 Shirts	Sell 8 Shirts
Holly	Buy 4 Shirts	(125.05; 15.01)	(137.94; -4.74)	(150.83; -32.00)
	Buy 6 Shirts	(112.16; 15.01)	(132.06; 11.26)	(144.95; -16.00)
	Buy 8 Shirts	(99.27; 15.01)	(119.17; 11.26)	(127.31; 0.00)

Analysis

This game has a single pure strategy Nash equilibrium: Holly buys four shirts and Angie sells four shirts. However, at this point in a game theory/micro principles course, this exercise should be trivial. Instead, the main pedagogical advantage of this type of game is that it entices students to ask “Where the numbers come from?” and “What is the ‘common sense’ meaning behind each of these numbers?” In doing so, this single, simple game allows instructors a starting point from which to introduce a number of economic concepts and the relationship between economic concepts. This game illustrates the relationship between utility maximization, profit maximization, and a plausible rationale (which applies to perfectly competitive markets, since price is taken as given) for the “invisible hand” that clears the market and equates the quantity supplied with the quantity demanded.⁷ In addition, students can visually see how demand and supply are shaped by consumer and producer theory in two dimensions.

In this game, Holly’s utility function is given by the equation $U = 6.576556(Q_d) - 1.203443(Q_d)^2 + 2.529045(M) - 0.599033(M)^2 + 6.444935(Q_s - Q_d)$, where M is the quantity of movies, Q_d is Holly’s quantity demanded for shirts, and Q_s is Angie’s quantity supplied. Holly arrives at her payoffs by choosing quantities for Q and M that exhaust her budget ($200 = 12M + 8Q$).⁸ When the instructor identifies this equation and fills in the table with the relevant numbers, it is also possible to illustrate how the signs and magnitudes of the utility function’s coefficients impact Holly’s well-being. This, in turn, can facilitate a discussion on the assumptions underlying utility theory, including (but not limited to) the law of diminishing marginal utility.

Normally, Holly’s optimal choice requires her to maximize her utility subject to her budget constraint. A standard principles approach is to demonstrate this numerically by using the utility equation to create and fill in a table with total utility, marginal utility, and marginal utility to price ratios. However, the process of finding the Nash equilibrium gives us an additional way to demonstrate this numerical computation, since it inherently involves marginal decision-making. By finding and comparing the numbers in the table to the payoffs of the game and by solving for the Nash equilibrium of the game, students are more easily able to see how the process of utility

⁷ It is important to note that we do not argue that a single game such as this can be used in place of traditional market equilibrium analysis, utility maximization, or profit maximization theory. Instead, the benefit of our approach is that it is an additional tool to supplement and clarify certain aspects of the traditional theory. Alternatively, if one were intent on teaching all of these concepts using game theory, it would be advisable to present a series of simpler games, where each game emphasizes one of these concepts.

⁸ See the discussion on the market-clearing mechanism presented below.

maximization leads to quantities demanded within a market. This is typically a challenging principle for students to grasp.

Similarly, an analysis of Angie's payoffs allows instructors a simple framework within which to motivate the idea of profit maximization. In our case, total revenue is the price for the product times the number of shirts *actually sold*, while costs are based on the number of shirts *offered for sale*. The total cost function is given by $TC = 0.493565(Q_s) - 0.938304(Q_s)^2$. As before, instructors may wish to use these functions to develop tables of quantities, revenues (both total and marginal), and costs (again, both total and marginal) to demonstrate how the payoffs were calculated and how acting on the margin leads to higher profitability for Angie.

A final advantage of game theory is that it allows for a clearer discussion of how the "invisible hand" acts to clear markets. Normally, instructors use simple demand and supply curves to illustrate surpluses or shortages and then show how a change in price clears the market. However, the intuition behind this bargaining process (in terms of the objectives of consumers and producers) is not specifically addressed. In game theory, identifying this mechanism is critical to solving the game. There are several ways to incorporate market-clearing mechanisms into games, depending on the game's assumptions and setup.

Because price is fixed in our game, we utilized a market mechanism that adjusted quantities. In particular, we made three assumptions. First, Holly can only purchase and consume as many shirts as Angie is willing to sell, and Angie can only sell as many shirts as Holly is willing to buy. Thus, if Angie is only willing to sell four shirts, Holly cannot consume 6 shirts even if she wants to do so. In such cases, she must buy the four shirts and spend the remaining \$16 on movies. Similarly, if Holly only wants to buy four shirts, Angie cannot sell her six shirts. Second, Angie's revenues are based on the number of shirts *actually sold*, while costs are based on the number *offered for sale*. For example, if Holly wants to buy four shirts while Angie offers six shirts for sale, then Angie's revenues are based on four shirts sold, while costs are based on six shirts offered. In essence, Angie has a significant cost of carrying inventory, which erodes profit. Last, the final term in Holly's utility function implies that she receives positive utility from having a large available selection of goods (i.e., a market surplus) and a negative utility from a shortage of goods. That is, Holly enjoys knowing that she does not have to go to multiple stores to fulfill her shopping needs.

It is this conflict of interests that drives the market to equilibrium. Angie wants to offer exactly enough shirts to meet Holly's needs without accumulating excess inventory. Similarly, Holly wants a large enough selection to meet her needs while simultaneously purchasing enough shirts to keep Angie in business.

A Simple Cournot Example to Illustrate the Use of Economics and Game Theory as a Primer for Subsequent Business Courses

Two small business owners—Ray and Alice—each independently own and operate a drive-through coffee shop in a small Oregon town. Based on past experience and the town's small population, both Ray and Alice are reasonably sure they don't have to worry about other firms entering the market. Both firms (noncooperatively) compete by producing and selling "lattes." Through a combination of experience and some basic spreadsheet modeling, both individuals know that prices within the market are based on the total number of lattes sold by both firms: $P = 4.50 - 0.02*Q$, where Q is the combined output of both firms ($q_{\text{Ray}} + q_{\text{Alice}}$) any given morning and P is the market price. Total costs can also be expressed in terms of output; Ray's total costs are given by $TC_{\text{Ray}} = 50 + 0.25q_{\text{Ray}}$, and Alice's total costs are $TC_{\text{Alice}} = 57.5 + 0.20q_{\text{Alice}}$. Holding constant all other factors and assuming that both Ray and Alice are simultaneously and independently interested in maximizing their own profit (and not trying to explicitly drive the

other firm out of business regardless of profitability considerations), how much output should each firm produce? How profitable is each firm?

Analysis

There are several equivalent methods of solving this game: through the explicit use of equations (which requires algebra and possibly calculus), graphical analysis using reaction curves, or by constructing a normal form game. To be consistent with our previous discussion, we choose the normal form. However, this method implicitly assumes that students are provided with several possible production levels for each firm, at least one of which represents the algebraic solution. Failure to do so will produce a Nash equilibrium that only approximates the true algebraic solution. In our case, we allow each firm to choose between three possible output levels, which differ by firm. Our normal form game takes the following form:

		Alice		
		Produce 70 Lattes	Produce 72.5 Lattes	Produce 75 Lattes
Ray	Produce 65 Lattes	(50.75; 54.5)	(47.50; 54.875)	(44.25; 55.00)
	Produce 70 Lattes	(51.50; 47.50)	(48.00; 47.625)	(44.50; 47.50)
	Produce 75 Lattes	(51.25; 40.50)	(47.50; 40.375)	(43.75; 40.00)

The Nash equilibrium of this game is for Ray to produce 70 lattes while Alice produces 72.5 lattes.

As mentioned earlier, the use of game theory (and Cournot models in particular) to describe the outcome of oligopolistic competition is standard at every level of economics. However, little attention is paid at the principles level to showing how the outcome of competition is fundamentally tied to the assumptions of the game. These assumptions, in turn, are largely drawn from industry analyses (such as five forces analyses, business plans, and SWOT analyses commonly taught in strategic management), marketing research, and information within the firm about its cost and production conditions. By discussing how these assumptions impact the outcome of the game, students can gain a better understanding of the relationships between principles of economics and other core business courses such as marketing, operations management, and strategic management. At the simplest level, this can be accomplished by asking students to place an economic meaning behind the relative values of each of the coefficients in the demand and cost curves. This, in turn, can be used to make inferences about consumer valuations for both products as well as the core competencies of each firm. For example, the fact that the slope coefficients of the demand function are the same (-0.02) implies that consumers in the market view the output of both firms as perfect substitutes. Concomitantly, different slope values imply imperfect substitutability. The intercept of the demand curve gives the maximum price consumers are willing to pay for a latte. Last, the relative magnitudes of the intercepts and slopes of the cost functions imply that Ray holds an advantage in fixed costs while Alice has a relative advantage in variable costs.

Instructors can also ask *why* Alice has a higher market share than Ray and which of the numbers (competitive advantages or disadvantages) described above contribute to this outcome. Clearly, Alice has a higher market share because she has an advantage in variable (and marginal) costs. This can also be used to illustrate why fixed costs are generally ignored when deciding how

much to produce. Principles books usually mention that marginal costs do not include fixed costs, and thus fixed costs are ignored when determining profit-maximizing output levels. Our game theory example clearly and concisely illustrates this fact. Moreover, principles texts often place less emphasis on the fact that, in the short run, fixed costs *do* matter. In our game, this concept can be illustrated by illuminating the discrepancy between market share and profitability. In this case, Ray has a lower market share but a higher level of profit. By working through the payoff calculations in the normal form of the game, we can see that this is due to Alice having higher fixed costs and lower variable costs. Thus, while Alice may be more successful than Ray in the long run by spreading out her fixed costs, in the short run she is actually worse off.

Third, instructors can illustrate the relationship between economics and other business courses by asking students to pick a particular firm and posit some recommendations about how to improve profitability. One response might be to implement an advertising campaign to differentiate Ray's product from Alice's. Class discussion should center on the benefits and costs of advertising. The benefit is that, if the advertising campaign is successful, Ray will be able to successfully differentiate his product and increase his revenue compared to Alice. Depending on the type of advertising campaign implemented, Ray may increase the maximum price consumers are willing to pay but not significantly impact consumer perceptions of product substitutability. In this case, Ray may be increasing his revenue but may also be helping Alice's as well. On the other hand, advertising is expensive, and implementing the campaign will also increase Ray's costs. Whether the campaign is worth doing depends on the relative magnitudes of its costs and benefits, and students should be encouraged to work through a few variations of the game with different cost and demand parameter values. This, in turn, can lead to a discussion of how to most effectively implement the advertising campaign given the benefits and costs, which can also lead to a discussion of the concepts students can expect to learn in their upper-level marketing course(s). Questions about how these parameter values are determined could also lead to a brief discussion of the concepts and tools discussed in a marketing research course.

Another possible response is for Ray's firm to make changes in the production process that reduce variable costs and gain economies of scale. In this case, discussion should focus on what avenues might be available to a firm such as Ray's to reduce variable costs. This allows the instructor to introduce some operations management concepts, including (but not limited to) the basic theories underlying supply-chain management and just-in-time manufacturing systems.

Conclusions

Game theory has become a commonly used tool in economics and permeates virtually every level of economic education except the principles level, where it is constrained to the oligopoly sections of microeconomics courses. In this paper, we have argued that game theory can and should become a more pervasive element in principles of microeconomics courses. Four elements make game theory a powerful and, as of yet, underutilized teaching tool.

First, game theory can be taught at an introductory level, requiring no more mathematical background than basic arithmetic. An additional strength of teaching a game theory based micro course is that the instructor needs to introduce only one set of standardized tools to analyze economic decision-making; thus the course becomes more focused on teaching economic principles and less focused on teaching economic tools.⁹ Third, because game theory requires instructors to adopt a case-study method of teaching, it is much easier to introduce the "really cool stuff" advocated by Becker without sacrificing the rigor of the course. The "really cool stuff" essentially shapes the rules (assumptions) under which the game is played. Last, game theory forces students (particularly those majoring in business or social sciences whose content overlaps with

⁹ In this paper we analyzed micro-oriented topics using only normal form games with pure strategy Nash equilibria. The addition of dynamic games, as well as normal games with mixed strategy equilibria, would allow an instructor an even greater amount of flexibility to teach economics using game theory.

economics) to think critically in a way that allows them to synthesize material across disciplines. Introducing concepts within the construct of a simple game encourages students to look beyond the outcome of the game to the underlying assumptions about consumer preferences, firm goals, market structure, and the interplay between these forces, which are the focus of other business and social science courses. In doing so, the course facilitates a more effective learning environment for students, since they are able to more clearly see the usefulness and importance of learning economics.

It is important to note that this research presents only a first step in developing a game theory/micro principles course. Future research is necessary to more fully investigate the attributes and detriments of the pedagogical approach. While we have demonstrated several additional pedagogical uses of game theory in micro principles, we have not developed a comprehensive microeconomics curriculum. Additionally, there are significant opportunity costs to utilizing this approach. If an instructor wishes to utilize this paradigm in addition to the traditional neoclassical micro tools, time constraints will force the instructor to either cut material from the course or cover existing material in less detail. Until a standardized, game theory based micro principles curriculum is developed, it will be difficult to determine the magnitude of these costs. These costs may also vary depending on the needs of students taking the course. It is likely that these costs are lower for business students and students who need to satisfy general education requirements. On the other hand, the costs for economics majors may be higher, since they need a strong background in neoclassical principles in order to take upper-level economics courses. Finally, there is also an opportunity cost in that instructors may be loathe to abandon their current pedagogical approach due to the time commitment of re-designing their course materials. Further work must be done to demonstrate to faculty that the increase in student learning justifies the additional time commitment.

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