A PUZZLE ABOUT ECONOMIC EXPLANATION: EXAMINING THE COURNOT AND BERTRAND MODELS OF DUOPOLY COMPETITION

by

JONATHAN NEBEL

B.S., Kansas State University, 2013

A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF ARTS

Department of Economics
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2015

Approved by:

Major Professor
Dr. Peri da Silva

Copyright

Abstract

Economists use various models to explain why it is that firms are capable of pricing above marginal cost. In this paper, we will examine two of them: the Cournot and Bertrand duopoly models. Economists generally accept both models as good explanations of the phenomenon, but the two models contradict each other in various important ways. The puzzle is that two inconsistent explanations are both regarded as good explanations for the same phenomenon. This becomes especially worrisome when the two models are offering divergent policy recommendations. This report presents that puzzle by laying out how the two models contradict each other in a myriad of ways and then offers five possible solutions to that puzzle from various economists, philosophers of science, and philosophers of economics.

Table of Contents

List of Figures

Acknowledgements

I would like to thank my major professor, Dr. Peri di Silva, for his helpful comments, ceaseless encouragement, and calm patience as we worked through all of the details of this report. Thank you to Dr. Bill Blankenau and Dr. Leilei Shen for serving on my supervisory committee. Members of the philosophy department at Kansas State University, Bruce Glymour, Elliott Wagner, and Graham Leach-Crouse, have been very helpful. Finally, thank you to all of my family and friends who have been so supportive of me through my time at Kansas State University.

Dedication

To Dr. Dennis Weisman, whose Industrial Organization class served as both the genesis of this report and as a rekindling of my passion for economics.

Chapter 1 - Introduction

One of the primary aims of scientific study is to explain phenomena. We aim to answer why-questions that crop up when we examine the world around us. The field of economics is no different in this respect to all the other sciences. Why does the price of a good increase? Why does one country grow at a faster rate than another? Why does an increase in the money supply correlate with an increase in the price level? These are the types of questions that require explanations for answers.

In this paper, I will examine one specific why-question within economics: why can firms price above marginal cost? Economists have many answers, but we will examine two of them in particular: the Bertrand and Cournot duopoly models. The economic community seems to regard both as good answers to the general why-question, but they cannot both be true, because they contradict themselves in important ways, including in the policy recommendations that they offer. This is the puzzle that will be the center of our inquiry. In Chapter 2, I will give an explanation of each of the two models that we will be examining and point out how they contradict. In Chapter 3, I will present some brief philosophical background on the concept of scientific explanation before giving a precise form of the puzzle that we will seek to solve by offering five possible solutions to the puzzle. Chapter 4 will include some concluding thoughts. Before embarking on that, I want to offer a few words on how this sort of interdisciplinary discourse is a possible useful venture.

1.1 - Economists are Philosophers (and vice versa)

The way that the typical university is organized creates a sharp divide between disciplines. The economists stay in their department, while the philosophers stay in their corner of campus. This physical and administrative divide should not seep into our academic work, though. Both fields have plenty of things to offer the other. I will focus here on what some philosophical tools can offer for answering an economic question, but that does not mean that

economics has nothing to offer philosophy.[1] Both fields ought to look at the other for possible insight.

The separation from philosophy is a peculiar historical fact. Many of the great minds who first developed the field were primarily philosophers. Sir William David Ross argued that "it must be remembered that in economics, as in so many other fields, Aristotle was almost the earliest worker."[2] Adam Smith, John Stuart Mill, David Hume, and Karl Marx all did important work in philosophy and economics.[3] The field of economics began with important contributions from the world of philosophy. Over time, the divide between the two fields began to widen. A typical view is that economics deals with hard data and facts, while philosophy deals with the world of values and that these two worlds must not touch, lest they dilute the power of each other. In economics, the distinction between valueless, positive economics and value-laden, normative economics is drawn early and often. Economists qua economists, we are told, are to avoid the use of values in their positive studies.

This divide ought not be as sharp today, though. Philosophers are beginning to look at the possibilities of using large amounts of data and economic-style experiments to test their theories. Economists, on the other hand, are increasingly recognizing the need to properly assess the foundations of their field, especially when it comes to its methodology and the fundamental purpose of their scientific endeavor. These are questions that philosophers of science have been asking. Further, with the growing influence of fields such as welfare economics and happiness economics, the relative importance of positive and normative economics has shifted.

With the collapse of the financial system in 2008, economists hit a perceived nadir as a group of intellectuals. The influential magazine, The Economist, wrote after the downturn that "of all the economic bubbles that have been pricked, few have burst more spectacularly than the reputation of economics itself."[4] Large numbers of economists seemed to be left largely blindsided by the sudden downturn with no real explanation for its causes and certainly no

---

[1] Game theory and public choice economics both offer great analytical tools, especially for political philosophers. Experiments about choice being conducted by experimental economics can offer insight into philosophy of action and philosophy mind. These are only a couple possibilities open to philosophers from the work of economists.
[2] Ross (1949). p. 213.
[3] Smith developed a theory of ethics and a philosophy of language. Mill is a foremost author on utilitarian ethics. Hume did influential work on induction and famously awoke Immanuel Kant from his intellectual slumber. Marx wrote extensively on political philosophy.
[4] What Went Wrong with Economics. (2009, July 18). *The Economist*.

prediction of it happening before it did. This has caused more economists to begin considering the underlying foundation of their field, which is precisely what philosophers have been doing. Economists have had to turn to assess the metaphysics (the theory of what the fundamental nature of being is) and epistemology (the theory of knowledge) behind their ideas. Philosophers of science have been asking these questions and can help provide the answers to some of these fundamentally economic questions. This intellectual interaction between the two fields can offer benefits for both sides.

Chapter 2 - The Models

2.1 - Perfect Competition

When economists want to examine market structures, they often start with the perfect competition model, which is an idealization of actual market structures. By using the results of the model and discovering how the real world differs from the perfect competition model in important ways, economists are able to learn things about the actual economic world. Here are the basic assumptions of the perfect competition model.

1) The number of buyers and sellers of the good is large enough that no single actor in the market has an impact upon the price. All firms are price takers.
2) Products within the market are homogenous. The goods sold by different firms are perfect substitutues.
3) All actors in the market have perfect information about price, quality, and other facts about the market and the goods on the market.
4) There are no barriers to entry to and exit from the market.

Some models invoke additional assumptions, but these four are the standard minimal assumptions and suffice for our purposes.

For our purposes the most important result is that *under perfect competition, price is equal to marginal cost*. Let me illustrate how economists get to this result in two ways. The first is by focusing on the price taking behavior of firms under perfect competition. We assume that the sole objective of firms is to maximize profits. In order to do this, firms must price where marginal cost is equal to marginal revenue. This is the necessary and sufficient condition for maximizing profits. In perfectly competitive markets, marginal revenue implies that price equals marginal cost due to the price taking behavior of the firms.

Let us now examine how this is explicated graphically, by examining the long-run equilibrium of the perfectly competitive market.

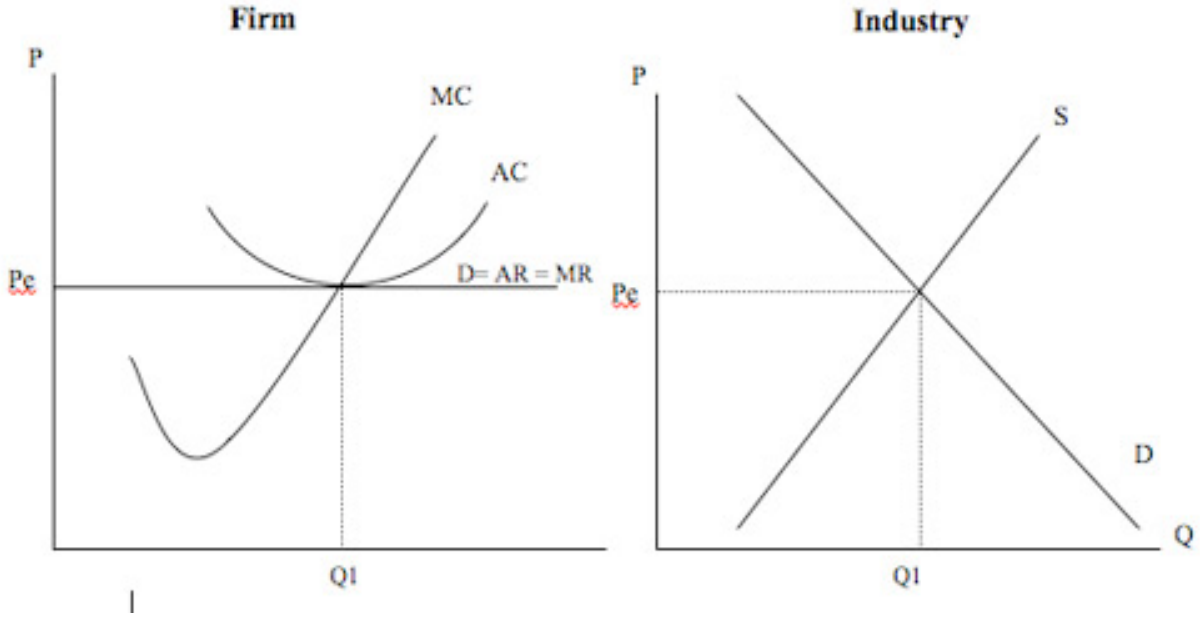

Figure 1

Figure 1 is a graphical representation of pefect competition. The left graph shows the relationships between price and quantity at the level of the firm. The right graph shows the relationships between price and quantity at the level of the whole industry. The market price (Pe) is set by the interaction of supply and demand at the industry level. By taking the price from the industry on the right and applying it to the individual firm graph on the left, we see that the demand curve for the individual firm is perfectly elastic[5] at the market price. This is what economists mean when they say that firms are price takers, as in the first assumption. Individual firms have no ability to change the price. If they raise it above Pe, they will sell no goods as they are undercut by their many competitors. If they lower it below Pe, they will be making a loss and go out of business. The firm has to take the price of Pe. As well as marking out the firm's demand curve, Pe allows us to identify the firm's marginal revenue (MR) curve. This is important, because the profit maximizing condition for a firm is to set marginal cost (MC) equal to marginal revenue. At this point, the firm gains more profit than at any other point.

[5] Elasticity is a measure of how responsive one economic variable is to a change in another economic variable. In this case, we are looking at demand elasticity, which measures how responsive the quantity demanded is to a change in the price. Demand is said to be perfectly elastic, if and only if any change in the price will cause quantity demanded to go to zero.

The final curve to look at is the average cost (AC) curve. The demand curve is tangent to the AC curve at the lowest point of the AC curve. This is another important consequence of the perfectly competitive market. If price were greater than average cost (which would happen if the supply curve was shifted to the left), then individual firms would be making profits. Because entry and exit into the market is completely free, if individual firms are making profits, then more firms will enter the market to gain profits. This will push the industry supply curve to the right, which will push the marginal cost curve downwards until it is at the minimum point of the average cost curve. If price was less than average cost (which would happen if the supply curve was shifted to the right), then the exact opposite process would take place; firms would freely exit the market as they make losses until the marginal cost curve is tangent to the average cost curve. This result means that in perfectly competitive markets, firms make no economic profits in the long run—any profit opportunity is swept away by the free entry of new firms onto the market—and *marginal cost is equal to price*.

Again: of these, the important result is that *under perfect competition, price is equal to marginal cost*, because price is equal to marginal revenue and profit maximizing firms set marginal cost equal to marginal revenue.

The problem is that when economists observe all the firms in the real world, they observe that there exist some firms that are pricing above marginal cost (and, thus, making a profit). We see companies like Airbus, Boeing, and Microsoft capable of making these types of profits. Companies are charged under anti-trust legislation due to monopolistic or oligopolistic behaviors. What is happening in these cases? That is the phenomena that needs to be explained: *some firms are capable, contra the implications of perfect competition models, of pricing above marginal cost*.

To explain why a result of the perfect competition doesn't show up in the real world, we need to relax alternative assumptions, and then examine which of the resulting models best matches data from the real world. Economists do just that with two different and (importantly, for our purposes) incompatible models, the Cournot and Bertrand models.

2.2 - Cournot Model

The Cournot model was developed by Antoine Augustin Cournot in 1838. His model contains many of the same assumptions as the perfect competition model (homogenous product,

firms maximize economic profits, firms do not cooperate, perfect information) with a few notable exceptions. Firstly and most importantly, firms are not price takers, because there are not a large number of firms in the market. Cournot drew up this model by examining a duopoly, a market with only two firms.[6] Due to the fewness of the firms, firms have market power, which allows them to have some degree of control over the market price. Secondly, the number of firms is fixed, so there is no free entry and exit. In fact, there is no entry or exit at all.

Thirdly (and crucially for distinguishing it from the Bertrand model), firms compete in quantities. Firms are assumed to have perfect knowledge of the market demand curve (which relates total quantity on the market to price), of their firm's cost curve (which relates their quantity produced to their total cost), and of their competitor's cost curves (which relates their competitor's quantity produced to their competitor's total cost). Given this knowledge, each firm examines how much quantity their competitors will produce. With the remaining or residual demand, that firm then acts as a monopolist and sets marginal cost equal to marginal revenue. The equilibrium quantity is set on the duopoly model by the intersection of the two firms' reaction functions, which relate how much one firm will produce to how much the other firm will produce. These reactions functions are plotted in Figure 2.

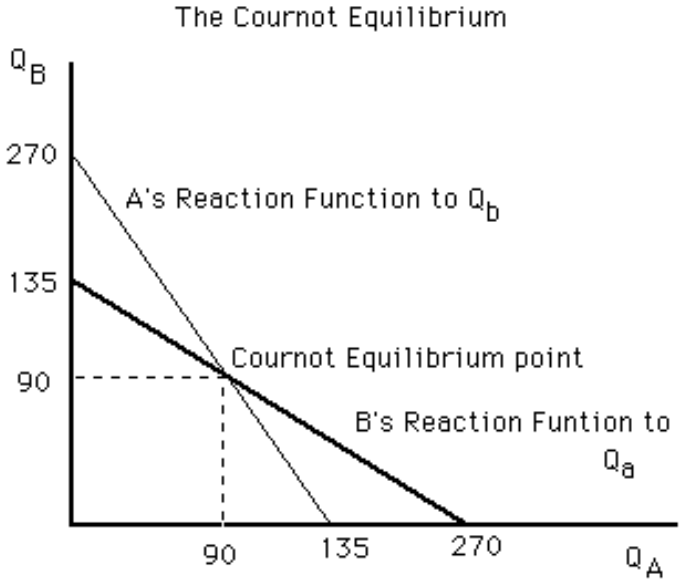

Figure 2

The basic assumptions of the Cournot model are:[7]

[6] Specifically, Cournot was examining a market for spring water that was dominated by two producers.
[7] Carlton & Perloff (2005). Ch. 6.

1) The number of buyers and sellers of the good is small enough that individual firms in the market can have an impact on the price. All firms are to some extent price makers. These firms compete on quantities.
2) Products within the market are homogenous. The goods sold by different firms are perfect substitutes.
3) All actors in the market have perfect information about price, quality, and other facts about the market and the goods on the market.
4) There are total barriers to entry and exit to the market. No new firms may enter and no firms may exit.

The results of the Cournot model are that the quantity produced falls somewhere between the amount produced by a monopolist and the amount produced under perfect competition. Similarly, the price is set between the price set by a monopolist and the price set under perfect competition. Specifically, price is set above marginal cost in relation to the Hirschman-Herfindahl Index (H) and the elasticity of the demand curve, according to the following equation.[8]

$$\frac{P - MC}{P} = \frac{-H}{\varepsilon}$$

P = price; MC = marginal cost; H = Herfindahl index; ε = elasticity of demand

The Herfindahl index is equal to the sum of the squares of all the market shares. For instance, if a market is under a duopoly and each firm controls 50% of the market, then $H = 0.5^2 + 0.5^2 = 0.5$. This means that the ability for firms to price above marginal cost is directly tied to the concentration of a market, as represented by their respective market shares, which provides them with market power.

According to Cournot, the ability of firms to price above marginal cost is explained by the fewness of firms that leads to restricted output and hence market power.

2.3 - Bertrand Model

The Bertrand model was developed by Joseph Louis François Bertrand in 1883 in his review of Cournot's book. Bertrand also begins by relaxing the first assumption of the perfect competition model. In contrast to Cournot, the Bertrand model has the duopolistic firms

[8] Lewis and McAfee (2012), Ch. 17.1. This assumes that the marginal cost is the same across firms in the market.

competing in prices. The firms choose the price that would maximize their profit. Given only this change in the assumptions of the perfect competition model, how do firms choose where to price? They price immedeately below their competitor. Since consumers will buy the good with the lower price, the firm with the lower price will take the entire market at the highest price possible.

In response, the other firm will price directly below their competitor. They will then recapture the entire market and maximize their profit. In response to that, the original firm will price just below this new price to recapture the market and maximize their profit. This process continues between the two firms until price is equal to marginal cost. With only two firms, the Bertrand model tells us that we will reach the perfectly competitive outcome, in which price is equal to marginal cost.

So, how then does Bertrand explain the ability for firms to price above marginal cost? The model relaxes another important assumption of the perfectly competitive markets: product homogeneity. This can be thought of in two ways. The first way is that the two goods might be in actuality the same thing, but that advertising and brand names causes consumers to value them differently. A good example can be found in the pharmaceutical aisle of your local grocery; you will find generic acetamatophin right next to Tylenol. Both bottles contain exactly the same chemical, but the bottle of Tylenol will be more expensive than the generic acetamatophin. The second way is that there are some important quality differences between the goods for which people will pay more. Consumers will pay more for oranges from one company, if their oranges are of higher quality.[9]

The basic assumptions of the Bertrand model are:[10]

1) The number of buyers and sellers of the good is small enough that individual firms in the market can have an impact on the price. All firms are to some extent price makers. These firms compete on prices.

[9] This distinction is not as clear as I am making it here. Tylenol might be importantly different from generic acetaminophen just because it is a brand name. This might give a placebo effect that makes Tylenol more effective. Further, brand names in themselves can be valuable because of the social status that it brings to have brand name goods over generic goods or to have the goods that famous people are advertising. These sorts of considerations might make these categories collapse into one.

[10] Carlton & Perloff (2005). Ch. 6.

2) Products within the market are heterogenous. The goods sold by different firms are not perfect substitutes. Advertising and quality differences can affect the market.

3) All actors in the market have perfect information about price, quality, and other facts about the market and the goods on the market.

4) There are total barriers to entry and exit to the market. No new firms may enter and no firms may exit.

According to Bertrand, the ability of firms to price above marginal cost is explained by product differentation, whether perceived by the consumers or actually in the quality of the product.

2.4 - How the Models Contradict

The Cournot and Bertrand models contradict each other in three main areas: their assumptions, their economic results, and their policy implications. Let us examine each area one by one.

2.4.1 - Assumptions

We will examine each assumption of the two models individually. Below are the first assumptions of the Cournot and Bertrand model rewritten for clarity's sake.

Cournot-1: The number of buyers and sellers of the good is small enough that individual firms in the market can have an impact on the price. All firms are to some extent price makers. These firms compete on *quantities*.

Bertrand-1: The number of buyers and sellers of the good is small enough that individual firms in the market can have an impact on the price. All firms are to some extent price makers. These firms compete on *prices*.

This is a subtle, yet important distinction between the two models. The phrase "compete on quantities" or "compete on prices" seems a bit clunky, but it describes well what is happening in the two models. Price and quantity are inextricably linked by supply and demand effects. The difference between the two models is which of the two variables the firms directly determines and which they indirectly determine through their choice. One is a choice variable; the other is determined by what the firms set their choice variable at.

Under Cournot, the firms directly determine the quantities that they will produce. Firm 1 chooses q_1 and firm 2 chooses q_2, q_i representing the quantity produced by the ith firm. Using these numbers, $q_1 + q_2 = Q$, representing the total market quantity. This quantity, Q, enters the market as the supply. Through interaction with the demand curve, a market price, P, is indirectly determined.

Under Bertrand, the firms directly determine the prices that they will set from their goods. Firm 1 chooses p_1 and firm 2 chooses p_2. Consumers demand goods based upon these prices and the market quantity is determined indirectly by the interaction of the demand curve with these prices.

One simple way to think about the distinction is to examine a demand curve graphed in price-quantity space as shown in Figure 3. The Cournot story is that the x-axis variable, quantity, is the independently chosen variable that determines price. The Bertrand story is that the y-axis variable, price, is the independently chosen variable that determines quantity.

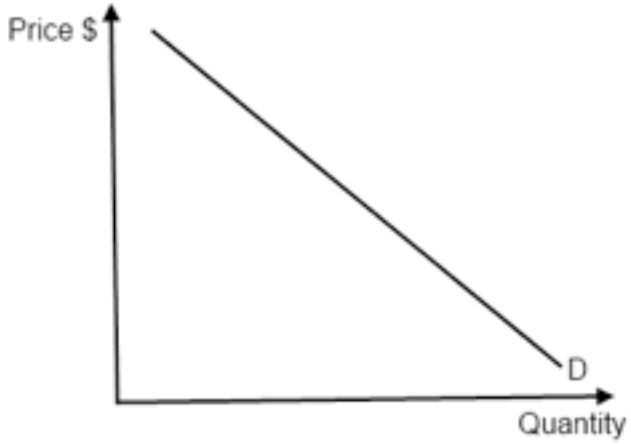

Figure 3

The important part of this for our purposes is that these two claims of the models are inconsistent. They cannot both be true. Cournot claims that firms compete on quantities. This implies that firms do not compete on prices, which directly contradicts the claim of Bertrand. The first assumptions of the two models cannot both be true.

Cournot-2: Products within the market are homogenous. The goods sold by different firms are perfect substitutes.

Bertrand-2: Products within the market are heterogenous. The goods sold by different firms are not perfect substitutes. Advertising and quality differences can affect the market.

The contradiction is most obvious in this assumption, where Bertrand assumes the direct negation of Cournot. Cournot assumes that the goods sold by different firms are perfect substitutes. Bertrand assumes that the goods sold by different firms are not perfect substitutes. It is impossible for both of these statements to be true.

Cournot and Bertrand share equivalent third and fourth assumptions.

2.4.2 - Economic Results

There is one obvious way that the two models contradict each other when it comes their economic results. Cournot and Bertrand disagree about what conditions are necessary for the market to reach the perfectly competitive result.

Cournot requires that many firms are required to reach the competitive result in the same way that the perfect competition model requires many firms. To see this, recall the equation given by the Cournot model:

$$\frac{P - MC}{P} = \frac{-H}{\varepsilon}$$

As the number of firms in an industry increases, H, the Herfindahl Index, get smaller and smaller. As H decreases, the gap between the price and marginal cost decreases until the market reaches the perfectly competitive outcome.

Bertrand only requires two firms for the market to reach the perfectly competitive result, as we saw above in the description of the model itself.

The two models contradict each other on what is the minimum requirements for a market to attain the perfectly competitive result. Bertrand states that a market with two firms is enough; Cournot states that a market with two firms is not enough. Cournot states that many firms are needed; Bertrand states that many firms are not needed. The two models' economic results are inconsistent.

2.4.3 - Policy Implications

This is where the puzzle attains some important "real world" implications. Along with other purposes, these models are to be used to offer recommendations for how to formulate public policy. This makes it even more important to find what the explanation is for the ability of firms to price above marginal cost. Bad policy can create harms to real people in the real world. It is no longer just an academic exercise; here, the economist bears a special type of burden,

because their work is so closely intertwined with public policy. What we find, though, is that these two models diverge in their policy recommendations, as well. Let us examine a series of papers that point out important divergences between the policy implications of the Cournot and Bertrand models.

Eaton and Grossman (1986)[11] – The paper begins with the simplest possible model of international trade. This model will start with no Cournot or Bertrand assumptions. It contains two countries with a single firm in each country that produces perfectly substitutable goods that are sold in a third country. The two firms compete in a duopolistic market. In this model, if there is no domestic competition, then trade policy becomes that same as industrial policy. The objective of the government in enacting policy is to maximize the sum of the home-firm's profit and their own tax revenue. The model will assume that the foreign government enacts no trade policy and examine what the best policy for the domestic government is.

Formally, this is presented as follows. The output (and thus, exports) of the home firm is denoted by x and its cost function is denoted by $c(x)$, where $c'(x) > 0$. Uppercase letters denote the corresponding quantities for the foreign firm with $C'(x) > 0$. Pretax revenue of the home and foreign firms are given by the functions $r(x,X)$ and $R(x,X)$, respectively, which satisfy the conditions that

$$r_2(x,X) \equiv \frac{\partial r(x,X)}{\partial X} \leq 0$$

$$R_1(x,X) \equiv \frac{\partial R(x,X)}{\partial x} \leq 0$$

These conditions state that an increase in the output of the competiting product lowers the total revenue of each firm. Total after-tax profits of the home and foreign firms are given by

$$\pi = (1-t)r(x,X) - c(x)$$

$$\Pi = R(x,X) - C(x),$$

respectively. In the first equation (for the home firm) t denotes the ad valorem output tax placed upon the good. The domestic firm's conjecture about the foreign firm's output response to changes in its own output is given by the parameter γ. The corresponding parameter for the foreign firm is Γ. Given these, the Nash equilibirum quantities, given the level of home country policy intervention are determined by the following first-order conditions:

[11] Eaton & Grossman (1986).

$$(1-t)[r_1(x,X)+\gamma r_2(x,X)]-c'(x)=0$$
$$R_2(x,X)+\Gamma R_1(x,X)-C'(X)=0$$

With this set-up, Eaton and Grossman prove that a positive output or export tax ($t>0$) can yield higher national welfare than laissez-faire if the home firm conjectures a foreign change in output in response to an increase it its own output that is smaller than the actual response.[12] Intuitively, this is because the policy intervention allows the domestic firm to act not as a typical competitor, but as a Stackelberg leader with respect to its competitor. The authors then examine what the optimal policy would be given Cournot assumptions and given Bertrand assumptions.

Under Cournot, each firm conjectures that the other firm will hold their output fixed in response to changes in their own output. In the formal language, this means that $\gamma = \Gamma = 0$. Given this, Eaton and Grossman find that an export subsidy raises domestic welfare by transferring industry-wide profits to the domestic firm. This finding is also consistent with Brander and Spencer's 1985 paper.[13] What they find is that an export subsidy allows the domestic firm to precommit to a higher level of output, making that firm an effective Stackelberg leader. This transfers industry profit to the domestic firm. The domestic firm benefits at the expense of the foreign firm. Under Cournot assumptions, the optimal trade policy is an export subsidy.

Under Bertrand, each firm conjectures that the other firm will hold their price fixed in response to changes in their own price. Given this, Eaton and Grossman find that the optimal policy is to implement an output or export tax. The logic is similar to the Cournot case in that the tax allows the domestic firm to act as a Stackelberg leader and precommit to a higher price. In contrast to the Cournot-based export subsidy, this tax causes price to rise and quantity to decrease. It also increases the profits of the foreign firm by relieving the duopolistic rivalry.

Cournot advocates for a subsidy; Bertrand advocates for a tax. The outcomes of these two policies are divergent, as well. The subsidy under Cournot simply moves profits from one firm to the other. The tax under Bertrand causes prices to rise, quantities to fall, and profits of both firms to increase.

Suetens and Potter (2007)[14] – When a market is dominated by two firms, the duopolists will sometimes explicitly agree to form a cartel or make some sort of agreement to achieve monopolistic profits. When this type of explicit agreement is made illegal or would make the

[12] Ibid, p. 388-389.
[13] Brander & Spencer (1985).
[14] Suetens & Potters (2007).

companies look bad, the duopolists might still engage in tacit collusion. They will take certain informal actions, such as foregoing opportunities to undercut their competitor, that maintain the duopoly. The two firms tacitly agree to play a specific strategy.

Suetens and Potter use past data from people interacting in pre-arranged Cournot and Bertrand settings in an effort to determine which setting is more likely to produce tacit collusion between the competitors. Before directly examining the data, they calculate a theoretical index of the scope for tacit collusion. This is referred to the Friedman index, as it comes from James Friedman.[15] The index is simply a ratio between the theoretical gains from cooperation and the theoretical gains from defection, written as $\frac{\pi_{JPM} - \pi_{Nash}}{\pi_{Defect} - \pi_{JPM}}$, where π_{JPM} is the profit earned under joint profit maximization or collusion, π_{Nash} is the profit earned under the Nash equilibrium, and π_{Defect} is the profit earned by defecting. For the various experimental arrangements, the authors calculate the theoretical benchmarks for price, quantity, and profit. Using these numbers, they calculate the Friedman index. What they find is that the Friedman index is consistently greater in the Cournot arrangements than in the Bertrand arrangements. They have *a priori* reason to think that tacit collusion is more likely under Cournot than Bertrand.

In examining the data, the authors develop an new index that is similar to the Friedman index to examine the tendencies towards tacit collusion. This new index is required in order to make use of the data from the experiment rather than using the theoretical benchmarks. The degree of collusion of oligopoly *k* in round *t* is defined as:

$$\rho_{kt} = \frac{\bar{x}_{kt} - x_{Nash}}{x_{JPM} - x_{Nash}}.$$

This index is calculated with both $\bar{x}_{kt}$ representing the average price and representing the average profit, so that for each oligopoly *k* and for each round *t* there are two values of ρ_{kt}, one using average price and one using average profit. If $\rho_{kt} = 0$, then oligopoly *k* behaves like an average oligopoly, according to the Nash equilibrium in round *t*, because the numerator will be equal to 0. If $0 < \rho_{kt} \leq 1$, then oligopoly *k* in round *t* is collusive. If $\rho_{kt} < 0$, then oligopoly *k* in round *t* is more competitive than the Nash equilibrium. That is because the index is a ratio

[15] Friedman (1971).

between the actual gap between price/profit and the Nash equilibirum and the theoretical gap between price and profit.

Using this index, they find:

$$\bar{\rho} = \frac{1}{NT}\sum_{k=1}^{N}\sum_{t=1}^{T}\rho_{kt}\,.$$

This is a simple sum of all the ρ_{kt} values across all oligopolies k and all rounds t. The $\bar{\rho}$ value for the Cournot and Bertrand experiments is then calculated. Their experimental findings contrast with what the Friedman index predicted. What they find is that the $\bar{\rho}$ values are consistently greater for the Bertrand experiments than the Cournot experiments. Bertrand markets, therefore, contain more tacit collusion between firms.

Figure 4 displays the results from the experiments. The bolded titles along the first column differientate between the different data sets. For each data set, the authors provide eight $\bar{\rho}$ values: one under Cournot using price for x, one under Cournot using profit for x, one under Bertrand using price for x, one under Bertrand using profit for x, and those four duplicated for two slightly different types of experiments that were done, BASIC and EXTRA. Under EXTRA, the participants were given more information before making their price or quantity decisions. N is the number of experiments that were done in each data set. For each data set a p-value is provided to show the statistical significance of the difference between the Cournot and Bertrand outcomes.

This finding has important policy implications. If it is the case that tacit collusion is more prevalent under Bertrand than under Cournot, then that will make a difference for anti-trust policy. If Bertrand is the explanation for the ability of firms to price above marginal cost, then more policy must focus on the possibility of our oligopolists colluding in more subtle ways. If Cournot is the explanation, then it would be a waste of resources to focus so much on tacit collusion.

	BASIC $\bar{\rho}$			EXTRA $\bar{\rho}$		
	Price	Profit	N	Price	Profit	N
FS duopoly						
Cournot	−0.12 (0.16)	−0.53 (0.36)	16	−0.24 (0.70)	−1.37 (1.70)	11
Bertrand	0.24 (0.15)	0.14 (0.20)	17	0.52 (0.26)	0.44 (0.34)	10
p-value	0.000	0.000	33	0.002	0.005	21
FS triopoly						
Cournot	−0.24 (0.18)	−0.70 (0.49)	16	−0.25 (0.19)	−0.78 (0.49)	11
Bertrand	0.09 (0.07)	−0.25 (0.26)	17	0.18 (0.06)	−0.31 (0.26)	10
p-value	0.000	0.010	33	0.000	0.004	21
HNO						
Cournot	0.01 (0.03)	−0.05 (0.15)	6	−0.23 (0.15)	−0.63 (0.38)	6
Bertrand	0.04 (0.07)	0.05 (0.12)	6	0.04 (0.06)	−0.01 (0.07)	6
p-value	0.394	0.394	12	0.004	0.002	12
Davis						
Cournot	0.14 (0.54)	−0.38 (1.01)	5	−0.50 (0.09)	−1.48 (0.33)	5
Bertrand	−0.10 (0.02)	−0.24 (0.06)	5	−0.05 (0.03)	−0.12 (0.07)	5
p-value	0.151	0.151	10	0.008	0.008	10
ALS						
Cournot1	−0.70 (0.82)		18	−0.86 (0.69)	−3.38 (2.57)	10
Cournot2	−1.30 (0.47)		18	−1.88 (0.31)	−8.60 (1.96)	10
Bertrand	0.75 (0.43)		18	0.08 (0.36)	−0.83 (0.89)	10
p-value1	0.000		36	0.006	0.011	20
p-value2	0.000		36	0.000	0.000	20

Standard deviations are in brackets and p-values refer to a Mann-Whitney-U test.
N = number of independent observations for FS, HNO, Davis and ALS EXTRA and number of players for ALS BASIC.

Figure 4

Ghosh and Mitra (2010)[16] – Mixed markets are markets where private firms, who are assumed to be maximizing profits, compete with public firms, who are assumed to be maximizing welfare. Introducing public firms often results in economic outcomes that can be very different from what the standard models predict. Ghosh and Mitra introduce a public firm into the Cournot and Bertrand models and examine how the two models differ. Their models are

[16] Ghosh & Mitra (2010).

of duopolies, where a single private firm competes with a single public firm. Here are their findings:

1) The public firm's output is strictly higher in Cournot than in Bertrand, whereas the private firm's output is strictly lower.
2) The profits of both firms are strictly lower in Cournot than in Bertrand.
3) Welfare is strictly higher in Bertrand than in Cournot as long as the private firm's price is weakly lower under Bertrand.
4) If you have a linear demand structure, then consumer surplus is strictly higher under Cournot than under Bertrand.

All of these findings have important implications for policy surrounding the creation of public firms. Let us examine the defense of their first finding. In Figure 5, we have the reaction functions of the public firm, WW, and the private firm, PP, plotted in (q_1, q_2) space, where q_1 is the quantity produced by the public firm and q_2 is the quantity produced by the private firm. The intersection of the two curves at point C is the Cournot equilibrium. The shaded area represents possible points of Bertrand equilibrium.

We know that $\frac{\partial W(q)}{\partial q_1} = 0$ for all q on WW and that $\frac{\partial^2 W(q)}{\partial q_1^2} < 0$. Given these facts, it follows that any q that satisfies $\frac{\partial W(q)}{\partial q_1} > 0$ must lie to the left of WW. We have a similar line of logic for the private firm. We know that $\frac{\partial \pi_2(q)}{\partial q_2} = 0$ for all q on PP and that $\frac{\partial^2 \pi_2(q)}{\partial q_2^2} < 0$. Given these facts, it follows that any q that satisfies $\frac{\partial \pi_2(q)}{\partial q_2} < 0$ must lie above PP. With those two results, it follows then that (q_1^B, q_2^B) must lie in the shaded region to the left of WW and above PP. Since for all q in the shaded region, $q_1 < q_1^C$ and $q_2 > q_2^C$, then $q_1^B < q_1^C$ and $q_2^B > q_2^C$. Therefore, the public firm produces a higher quantity under Cournot, whereas the private firm

produces a higher quantity under Bertrand.

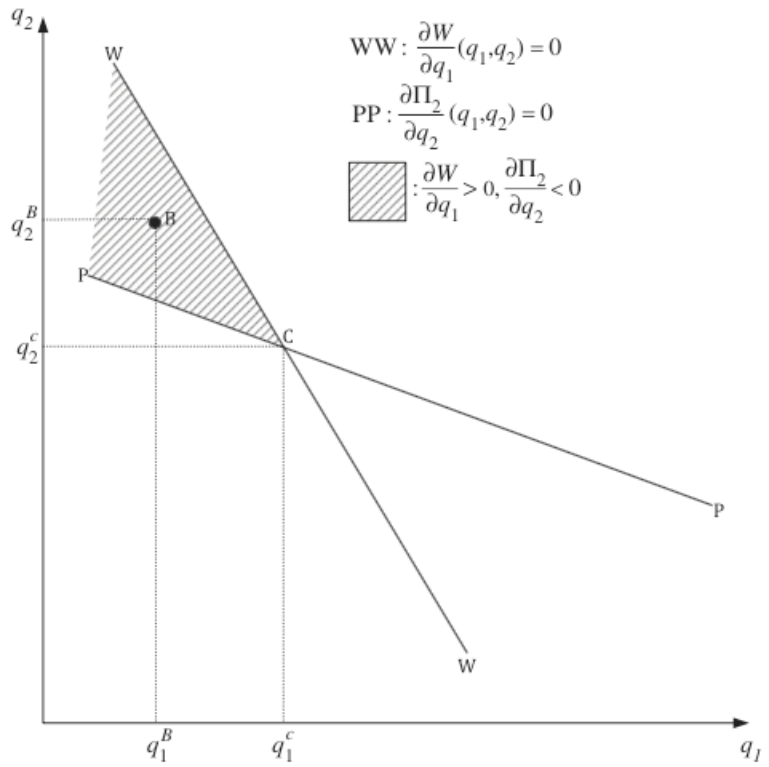

Figure 5

Given this result, we have differing implications for best use of public firms. Cournot would imply that public firms are better used where you want them to take a more central role in the market, whereas Bertrand would imply that public firms are better used where you want them to play a more supplementary role along with already existing private firms, because the public firm's output is higher under Cournot. The second finding has important implications for how to best fund a public firm. Bertrand would predict that a public firm would be more capable of funding itself, whereas Cournot would predict that a public firm might need funding in the form of taxes to make sure that the public firm stays afloat, because profits are strictly higher under Bertrand.

Chapter 3 - Scientific Explanation and Solving the Puzzle

So far, I have offered some words about explanations and how Cournot and Bertrand are meant to explain the fact that firms can price above marginal cost. Here is where I hope to make the concept of explanation more precise. To do this, we will first look at the historical formation

and evolution of this concept with the philosophy of science literature before examining how these concepts can be specifically applied to explanations within the realm of economics. Finally, a precise form of the puzzle will be presented, so that it will be clearer which part of the puzzle each of the proposed solutions are attacking.

3.1 - Scientific Explanation: The Received View

3.1.1 - What are explanations?

Explanations are answers to why-questions.[17] They help clear up matters and remove confusion. They serve a pragmatic purpose in helping illuminate facts about certain phenomenon that were previously hidden. Importantly, explanation is a separate, though related, goal of science from prediction, accuracy, adherence to evidence, etc. Namely, it is possible for a set of claims to be true, accurate, and well-supported by evidence, etc., but not to explain. So, what, then, makes something an explanation? What is it that makes our answers to our why-questions different from other claims made by scientists?

Any discussion of scientific explanation must begin with Carl Hempel. He argues that scientific explanations must meet two systematic requirements.[18] Firstly, an explanation must be explanatorily relevant. The sentences that are said to describe the phenomenon in question must be, in some meaningful manner, relevant to the phenomenon in question. An explanation of what stage of the life cycle a star is in based on what constellation it is a part of would fail this requirement. Being a part of Ursa Major or Orion has no relevance upon how the star is aging. Secondly, an explanation must be testable. Hempel offers a story of an explanation of gravity based on a love attraction between masses as being an explanation that fails on this requirement. An explanation must meet both requirements to be considered as the explanation for phenomena.

Explanation, as described by Wesley Salmon, has three intuitive views.[19]

1) Explanations show that the phenomenon to be explained was to *have been expected*.
2) Explanations show that the phenomenon to be explained was *necessary*.
3) Explanations reveal the *causes* of the phenomenon to be explained.

---

[17] Why does the apple fall off the tree? Gravity. Why is the price of eggs lower today than 100 years ago? Decreased productions costs.
[18] Hempel (1965).
[19] Salmon (1984).

The phenomenon to be explained is referred to as the *explanandum*. The set of sentences that are to explain the phenomenon is referred to as the *explanans*. For example, one could ask: why is it that a dropped apple falls towards the ground? The answer is: because gravity pulls the apple towards the Earth. In this case, the dropped apple falling towards the ground is the phenomenon that needs to be explained and, thus, the *explanandum*. Gravity pulling the apple towards the Earth explains the *explanandum* and, thus, the *explanans*. So, Salmon's views could be rewritten as:

1) The *explanans* show that the *explanandum* was to have been expected.
2) The *explanans* show that the *explanandum* was necessary.
3) The *explanans* reveal the causes of the *explanandum*.

These three views are very similar, but they have important differences and each has important benefits and problems for developing a view of explanation. Let us first, then, examine a more formal way to look at explanation.

3.1.2 - Deductive-Nomological Method

For all intents and purposes, the modern discussion around scientific explanation begins in 1948 with the publication of "Studies in the Logic of Explanation" by Carl Hempel. In this paper, Hempel lines out what is now called the deductive-nomological method. The view had begun to be developed by members of the Vienna Circle, a group of prominent philosophers who gathered at the University of Vienna, at the turn on the century, but it was Hempel who put forth the view in its most precise and succinct form.

According to Hempel, an explanation is composed of the *explanans*, which is made up of the initial conditions and a covering law, and the *explanandum*, which follows logically from the *explanans*. This is why we get the name of the method. It is deductive, because the form of the explanation is a logically valid argument, and it is nomological, because it requires the use of a scientific law. For example:

(IC): An apple is dropped near the surface of the Earth.

(L): An object dropped near the surface of the Earth will fall at a rate of 9.8 m/s^2

(C): The apple falls at a rate of 9.8 m/s^2

Jointly the initial condition (IC) and the covering law (L) make up the *explanans*. Given these two sentences, the conclusion (C) follows logically. Thus, we have an explanation for the

explanandum. In this way, an explanation takes the form of a logical argument. An explanation is a deductive argument where the premises are the *explanans* and the conclusion is the *explanandum*.

3.2 - Explaining Economic Phenomena

That was a brief look at the history of theorizing on scientific explanation, but it should be enough background to allow us to get into the core of assessing what we can do about explaining economic phenomena. Economists are constantly seeking after explanation. After any economic crisis, the public turns to the professional economists to give them an explanation for why the crisis occurred. When the price of an important good goes up, it is economists who must explain why that has happened. It should be clear that explanation forms a foundational part of the identity and purpose of economists and the study of economics.

How do we best accomplish this goal? Economists could go the way of Hempel and develop economic laws to place within the deductive-nomological method, but economists also have a special tool that is used to great aplomb. We have seen how economists have used the perfect competition, Cournot, and Bertrand models to explain real-world phenomena. Through the use of model building, economists are able to usefully explain real-world phenomena even with models that have unrealistic assumptions. In our case, we are able to do so by comparing how the results of the model change when we adjust assumptions in an idealized case.

With a brief background on the concept of scientific explanation, we can now give a formal version of the puzzle.

3.3 - The Puzzle Made Clear

(1) Firms are capable, contra the implications of perfect competition models, of pricing above marginal cost.

(2) The Cournot and Bertrand models are inconsistent.

- **a.** Models are explanatory.
- **b.** The Cournot and Bertrand models are explanatory of the same phenomenon.
- **c.** If two models are inconsistent and explanatory of the same phenomenon, then the explanans of their explanations are inconsistent.

(3) The explanans of the explanations offered by Cournot and Bertrand are inconsistent.

- **a.** At most one of a pair of explanations with inconsistent explanans can be good.

b. Only good explanations should be accepted.

(4) At most one of the explanations offered by Cournot and Bertrand should be accepted.

(5) Both explanations offered by Cournot and Bertrand should be accepted.

Premises (1) to (3b) together form an argument for (4). Let us offer some words in support for each premise.

(1) is the explanandum. (2) was shown to be true in section 2.4. (2a) is a widely-held belief among the economic community. (2b) is a fact about the two models. (2c) is a fact about the nature of explanations. Explanations are arguments from explanans to explanandum. If the models are inconsistent and at the same time being used to argue for the same explanandum, then the two explanations' explanans are inconsistent.

(3) follows from modus ponens from (2), (2b) and (2c). (3a) appeals to scientists' intutition that good explanations are true explanations. If two explanations have inconsistent explanans, then at most only one explanans can be true, so at most only one explanation can be good. (3b) states a truism that you ought to only accept good explanations. (4) follows from (3), (3a), and (3b). (5) is the belief that the economic community holds to. The puzzle is revealed by 4 and 5 being contradictory.

3.4 - Solving the Puzzle

In order to solve the puzzle, as given a clear form above, we must deny one of the premises for the argument for (4) or deny (5). We will examine five different ways to think solving the puzzle, each suggesting one of the statements for us to deny. For sake of summary and having the information in one place, here is the premise that each solution will attempt to deny.

Van Fraassen: (3a)

Incommensurate Values: (3a)

Reiss' Trilemma: (2a)

Mäki's Realism: (5)

Contextual Application: (2b)

3.4.1 - Van Fraassen

When presented with this sort of puzzle, the first thought of many philosophers of science might be the writing of Bas van Fraassen. In *The Scientific Image*, he describes a scene during

his travels along the Saone and Rhone rivers.[20] As he is enjoying meal on the terrace of the ancestral home of the Chevalier, a shadow from a nearby tower edges closer towards him. His sunny dinner spot will soon be very chilly. When talking to some others with him, he asks why the shadow will hit the terrace at that time and receives two explanations for the phenomenon.

The first relates the height of the tower and the angle of the sun to the position of the shadow. By describing how tall the tower is and where the sun is, we are able to explain why the shadow is now encroaching upon van Fraassen's meal. In this case, the explanans contains facts about the height of the tower, the angle of the sun, and the properties of light. Knowing these facts, we have a *physical* explanation for the shadow reaching the table.

However, later that evening van Fraassen is given a different explanation for why the shadow reaches the table. The tower marks the point where the Chevalier had killed his maid, with whom he had been madly in love, after discovering her cheating on him. The tower was built to be just high enough that at dusk the shadow of the tower would reach the balcony where they had first met and thus started their love together. Knowing these facts, we have a *historical* explanation for the shadow reaching the table.

Van Fraassen uses this as an example to show that explanations have an important pragmatic component. Explanations are answers to why-questions, so therefore the answers must in some way rely upon the person asking the question. "Scientific explanation is not (pure) science but an application of science. It is a use of science to satisfy certain of our desires; and these desires are quite specific in a specific context. […] The exact content of the desire, and the evaulation of how well it is satisfied, varies from context to context."[21] In the tower example, we have two alternative explanations for a single phenomenon. Both seem to be good explanations. How do we choose between them? Well, it depends on the desires and values of the person asking the why-question. If they are looking for a description of the scientific reasons, then we can appeal to the *physical* explanation. If they are looking for a description of the history that led to this state of being, then we can appeal to the *historical* explanation.

This seems like it could parallel our economic puzzle very well. We have a single why-question—why are firms capable of pricing above marginal cost?—and we have two alternative explanations—Cournot and Bertrand—that both seem to be good explanations. The solution

[20] Van Fraassen, p. 132-134.
[21] Van Fraassen, p. 156.

seems simple then. The explanation that ought to be appealed to should be the one that fits to the desires of the person asking the why-question.

When given the puzzle presented here, *van Fraassen would reject premise (3a)*, which states that at most one of a pair of explanations with inconsistent explanans can be good.

The analogy is not as simple, though. In the case of the tower, there is nothing inconsistent with the two explanations. It is logically possible for both the scientific and the historical explanations to be true and, in fact, it is the case that both explanations are true. In the economic case, the two explanations cannot both be true. The two models are inconsistent in important ways, as noted above.

The framework provided by Van Fraassen's tower example does not fit our economic problem. It is not the case that we have two alternative explanations that are consistent from which we may simple choose. Instead, we have two alternative explanations that directly oppose each other. They cannot both be true, yet both are still widely accepted as being so. I don't believe it is obvious that van Fraassen helps us fully resolve the puzzle.

3.4.2 - Incommensurate Values

We have seen that pragmatics can play an important part in our explanations, because explanations are answers to why-questions. It is generally thought that truth is still the ultimate criterion for the goodness of explanations, but this could be a mistake. Economists might have a more nuanced commitment to truth. Perhaps it is the case that economists are simply left with no way to rationally choose between the two models. Economists value, amongst other things, models that have true assumptions and models that make accurate predictions. The ideal model resembles the actual world to some extent and provides good predictions for how markets will function. The problem is that these two aims often conflict, and when they do, neither has lexical priority. Economists value these two things incommensurably. There is no way for them to compare their valuation of realistic assumptions in the model to their valuation of accurate predictions. They are both highly valuable, but incapable of being compared against each other.

This has an impact on our puzzle, because these two models each satisfy one of these two values much better than the other model does. The Cournot model has had the better predictive success. The equation that relates the gap between price and marginal cost to the Herfindahl

index and the elasticity of demand is a pretty good predictor of how markets actually function.[22] This equation is often used in anti-trust cases, because it can fairly reliably predict how a market will look after a merger is allowed to happen.[23] The Cournot model satisfies the economists' value for predictive accuracy.

On the other hand, the Bertrand model seems to have much more sensible and realistic assumptions. Namely, competitors will compete on prices in the actual world rather than on quantities. When one firm wants to try to take market share from their competitor, it will try to do so by lowering its price and making its good cheaper for consumers, rather than adjust the quantity produced.[24] The Bertrand model satisfies the economists' value for realistic assumptions better than the Cournot model.

In this way, *this solution would also reject (3a)*, which states that at most one of a pair of explanations with inconsistent explanans can be good. Economists have a more nuanced view of the truth of their models. The truth of a model has distinct dimensions; it can have more or fewer accurate predictions or more or fewer realistic assumptions. Because of this, truth cannot be used to decide between models, but rather truth-in-respect-of-predictions or truth-in-respect-of-assumptions must be used.

With these two values being incommensurable, economists have no way to rationally choose between the two models, so both models end up being accepted, because they both satisfy one of the highest values that economists look for in their models. This seems like a good description of what economists themselves are doing and how they wriggle out of this puzzle, but I am unsure if it is actually a satisfactory way to solve it.

3.4.3 - Reiss' Trilemma

In *Philosophy of Economics: A Contemporary Introduction*, Julian Reiss presents a paradox about explaining with economic models. Each statement of the paradox seems plausible on its own, but taken together the statements are inconsistent. These are the statements:[25]

---

[22] Hay and Werden (1993): "The Cournot model also is the only one for which it has been shown that price and output effects of mergers are well predicted by conventional measures of market shares and concentration." p. 174.
[23] Carlton and Perloff (2005), p. 613. The *Horizontal Merger Guidelines* that the Department of Justice and Federal Trade Commission use direct the government to first define the market and then to determine whether or not the merger will increase or decrease the Hirschman-Herdindahl Index.
[24] Hay and Werden (1993): "The Cournot model has endured a century of criticism. The oldest criticism is that setting prices rather than quantities is more realistic," p. 174.
[25] Reiss (2013), p. 127

1) Economic models are false.
2) Economic models are explanatory.
3) Only true accounts can explain.

To resolve the paradox, one must give up on one of the above premises. If we give up on premise 2, we have another possible way to solve our puzzle, as premise 2 in Reiss' paradox is equivalent to premise 2a in our puzzle. *Reiss' solution would reject premise (2a)*, which states that models are explanatory. Perhaps the reason that this puzzle arises is because economists falsely believe that their models are capable of explaining phenomena in the real world. Models might offer tools to develop hypotheses or help us learn modal facts,[26] but they cannot explain. We are simply mistaken when we use the Cournot and Bertrand models to try and explain why it is that firms can price above marginal cost.

It certainly seems, though, that models do in fact explain. It is true that models achieve other goals, but they are also used to explain phenomena in the world. To save this premise in the paradox, we must show that one of the other two is false. I will offer some of my own speculations on the first and offer thoughts from Robert Sugden on the third.

I want to offer a brief sketch of a possible story about how we can think of economic models being true. I am borrowing a concept from Christian theology related to Biblical inerrancy and apply it to assessing the truth-value of models. One theory of Biblical inerrancy states that what it means to say that the Bible is inerrant is to say that everything that the Bible teaches is true.[27] It is the case that the Bible gets certain facts, such as specific numbers, incorrect, but those statements are not teachings of the Bible. Everything that the Bible teaches is in fact true, if it is the case that the Bible is inerrant.

Similarly, one way of assessing the truth-value of a model is assessing whether or not what the model teaches is true or false. In this way many economic models would be true. Schelling's model of racial segregation teaches us that it is possible for racial segregation to not be the result of racism; Akerlof's model of the market for lemons teaches us that incomplete information can cause a market to collapse; Cournot and Bertrand teach us how it is possible that

[26] In fact, Reiss himself believes this is one important function of model building.
[27] The "Chicago Statement on Biblical Inerrancy" from 1978 states that "Scripture is without error or fault in all its teaching."

firms can come to price above marginal cost.[28] In this way, we have a plausible way to show that economic models can in fact be true. We thereby have reason to deny premise 1 in Reiss' paradox

We also have reason to deny premise 3 in the paradox. Robert Sugden claims that explanation is possible with unrealistic models. Let R be a regularity and F be a causal factor. Sugden argues that we use models to explain with the following form of argument:[29]

1) In the model world, R is caused by F.
2) F operates in the real world.
3) R occurs in the real world.
4) Therefore, there is reason to believe that in the real world, R is caused by F.

The logical inference to 4 is an inductive one. In the same way that we might observe a number of cities in the US and then induce facts about cities that we have not observed, models allow us to observe a number of possible worlds and then induce facts about the real world. "The gap between model world and real world can be filled by inductive inference. […] [Models] describe credible counterfactual worlds. This credibility gives us some warrant for making inductive inferences from model to real world."[30] The basic idea is that the real world is the most complex model there is; it includes every single fact. We are able to induce from simple models to more complex models (in much the same way that we did from perfect competition to our duopoly models). If you continue that inductive chain from possible worlds to the actual world, you are able to use the false models to explain things about the real world. In this way, false accounts are capable of explaining.

Reiss' paradox is a difficult one for those working in economic methodology. Reiss himself concludes that "the rational response to the paradox is to remain baffled."[31] At minimum, we have good reason to think that it is not the second premise of the paradox that needs to be thrown out, but rather one of the other two. This leaves us with our original puzzle still standing unscathed.

---

[28] Notice, in defense of Reiss claim about the importance of models for discovering modal facts, that these examples are all modal claims.
[29] Sugden (2000). p. 21.
[30] Sugden (2000). p. 31.
[31] Reiss, (2013). p. 141.

3.4.4 - Mäki's Realism

Uskali Mäki is the foremost proponent of realism in philosophy of economics. He argues for a realist approach to models in that he argues that models can possibly be true. He defends what he calls a functional decomposition approach. "It is a *decomposition account* since it relies on splitting models into bits and pieces rather than dealing with them as undifferentiated wholes. It is a *functional account* in that it is based on attributing distinct functions to those bits and pieces."[32] His formulation of models is as follows:

> Agent A uses object M (the model) as a representative of target system R for purpose P; addressing audience E; at least potentially prompting genuine issues of resemblance between M and R to arise; describing M and drawing inferences about M and R in terms of one or more model descriptions D; and applies commentary C to identify the above elements and to align them with one another.[33]

The functional part of Mäki's story is represented by the model being used for some purpose P and addressing some audience E. The decomposition part of the story is represented by the commentary C, which is used to identify the relevant parts of the model and the respect and the degree to which those parts are supposed to resemble the system R. Models are made up of various parts and each part has a different function. Mäki argues that one of those functions is to be the primary truth bearer. The model-purpose and model-audience relations are important pragmatic parts that alone cannot constitute truth. The model-system resemblance relation is key to truth, but as soon as you recognize that, you must introduce the purpose and the audience into the equation, because they are the ones that determine which parts of the model are important for assessing that resemblance relation. In this way, truth about models has both pragmatic and ontological constraints.

According to Mäki, we can assess the truth-value of a model. In this way, *Mäki's solution would reject premise (5)*, which states that both explanations offered by Cournot and Bertrand should be accepted. To solve the puzzle, the economist must use his theory of the truth-value of models to assess which is actually true. By examining the component parts of the two models

---

[32] Mäki, (2013). p. 9. Italics in original.
[33] Mäki (2009). p. 5.

and seeing how they resemble the world, economists should be able to decide which one is actually true or if they are simply both false. If one of them were true, Mäki would say that economists should accept that one and reject the false one. Until that work is done, the puzzle will remain.

3.4.5 - Contextual Application

This solution might be referred to as the economist's solution, as it is the one most often appealed to by the economist. The economist says that we are simply thinking about how to use these models in the wrong way. We are not seeking to explain some single phenomenon out in the world, but rather a variety of different phenomena. There are a huge number of markets in the world and these all behave in slightly different ways. What the economist does to assess a single market is to find the model that seems to best fit that specific market and then use that model to learn things about that market.

In this way, we observe specific firms that have the ability to price above equilibrium and we have different ways to explain why these specific firms are able to do this, namely our Cournot and Bertrand explanations. How do we determine which is the best explanation? We look at the specific properties of that market and see which model best maps onto those properties. In this way, *the contextual application solution would reject premise (2b)*, which states that the Cournot and Bertrand models are explanatory of the same phenomenon. Economists, according to this solution, are not about answering this broad question: why is it that firms can price above marginal cost? Instead, they are about answering a myriad of specific questions about why firm X can price above marginal cost.

This seems a temptingly simple and obvious solution, but I want to press on it by means of analogy.[34] Imagine that I create a Perfect Goldfish Model. This model has a number of assumptions about the life of a goldfish that allows the goldfish to live a full, prosperous, and fully efficient life. We assume that there are no cats around; we assume that the goldfish bowl is perfectly clean; we assume that the goldfish is fed the perfect food source. In our Perfect Goldfish Model, goldfish perform optimally, but we observe in the real world that there are goldfish that do not live a full, prosperous, and fully efficient life. Many die. We are left with a why-question that deserves an explanation: why is it that goldfish die?

[34] I am thankful to Graham Leach-Krouse for offering this insight.

In an attempt to explain why these goldfish are dying early, we might relax some of the assumptions of our Perfect Goldfish Model to observe how this changes our outcome. We relax the no cat assumption and develop the Shmournot Goldfish Model. What we see now is that goldfish die; in fact, they are killed by the cats! We have an explanation for our real-world phenomenon: cats kill the goldfish. But, we have a competing model, the Shmertrand Goldfish Model, which relaxes the assumptions that the goldfish bowl is perfectly clean. Again, we observe that goldfish die when their bowl gets very dirty. We have another explanation for our real-world phenomenon: dirty goldfish bowls kill the goldfish.

How does this help us answer our why-question? What have we learned about why it is that goldfish die? Well, it seems that we have learned about certain cases of goldfish death. We can explain certain cases where cats are nearby or cases where the bowl gets dirty, but we seem to be missing a larger question about why it is that goldfish even die in the first place.

To make this clearer, let us make an important distinction between types and tokens. This is an important ontological distinction between something more general and specific instances of that general thing. A famous example to demonstrate the difference comes from *Sacred Emily*, a poem written by Gertrude Stein. She writes:

"Rose is a rose is a rose is a rose."

One might ask after seeing this line of the poem: how many words are in this line? There are two answers. In one sense, there are three words ('rose', 'is', and 'a'). In another sense, there are ten words. In the first sense, we are counting the word *types*, whereas in the second sense, we are counting the word *tokens*. Types are general categories; tokens are specific instances of that type.

We can enumerate a few more examples to make the distinction clearer. There is the type *human being*, as well as each individual token in the form of you, the reader, your parents, and other human beings. There is this one type, but billions of tokens. There is the type *NBA franchise*, as well as a number of individual tokens in the form of the Memphis Grizzlies, Atlanta Hawks, and the other franchises. There is the type *planet*, as well as individual token in the form of Earth, Mars, and the other planets that orbit the Sun.

To apply it to our analogy, there is the type *goldfish dying*, as well as individual token of various goldfish dying. What our Shmournot and Shmertrand models seem to be doing is explaining the existence of certain specific tokens of goldfish dying, but it failing to grasp at the

type. It cannot explain why it is that goldfish die (or, to put it another way, why goldfish are mortal). The same, I argue, is true of our Cournot and Bertrand models. They are potentially capable of offering explanations for tokens of firms being capable of pricing above marginal cost, but are incapable of offering an explanation for the type *firms being capable of pricing above marginal cost*.

The response from an advocate of this solution might be to simply shrug their shoulders and carry on doing their economic study. Economics should not care about explaining these esoteric types and instead look to explain the tokens that we can directly observe and interact with. These are the things that policy makers are looking for us to offer answers about. These are the loci of our academic endeavor.

I am not sure if there is much more to be said other than that I fear the dismissal of the desire to explain these types might be too hasty. The market is an incredible web of complex interactions that should draw an awe equivalent to the one that astrophysicts feel when they look out into the universe. There is something immensely powerful about discovering some more fundamental truth about the types within this market web that makes me want to continue to dive deeper in search for them rather than settle for examining the individual tokens.

Chapter 4 - Conclusion

We have seen that the puzzle is not easily whisked away. We still have a single phenomenon, that firms price above marginal cost contra the implications of the perfect competition model, and two competiting explanations of that phenomenon, Cournot and Bertrand, that cannot both be true, yet are still both accepted as good explanations.

In assessing the five possible solutions, it seems to be that the second and the fifth are the closest to how economists themselves have come to resolve this puzzle. If the second is that important, this could have an impact on our understanding of explanation. If it is the case that economists are willing to accept these two contradictory explanations, because of conflicting aims related to the two, then we have good reason to think that something more than simple, undifferientated truth plays an important role the economist's assessment of the goodness of explanations. This is an interesting way that this puzzle shines light on questions about explanation. Could there be cases in other sciences where scientists are unable to decide between

explanations because of the incommensurability of their values? Is this a case unique to economics? If so, what does this mean for economics?

If it is the fifth solution that offers our best way out, than we are left with other important questions about the field of economics. What does this mean about the ultimate aim of economics? Are we only to find answers for why-questions related to individual tokens? Do types not play an important explanatory role for the economist? If so, why not and is there a different group who should be assessing these issues?

What one sees as the best response to the puzzle seems to open up other important questions about scientific explanation both in general and how it is accomplished by economics. Ultimately, just as Reiss said about his paradox, it seems that the most rational response to this puzzle is too remain baffled and search it out to discover new and interesting facts about the nature of explanation.

References

Bertrand, Joseph Louis François (1883). "Book review of theorie mathematique de la richesse sociale and of recherches sur les principles mathematiques de la theorie des richesses", Journal de Savants 67: 499–508.

Blaug, Mark (1980). *The Methodology of Economics, or, How Economists Explain*. Cambridge: Cambridge University Press.

Brander, James, & Spencer, Barbara (1985). Export Subsidies And International Market Share Rivalry. *Journal of International Economics, XVIII*, 83-100.

Carlton, Dennis & Perloff, Jeffrey (2005). Modern Industrial Organization (4th ed.). Boston: Pearson/Addison Wesley.

Cournot, Antoine Augistin (1838). *Researches on the Mathematical Principles of the Theory of Wealth*.

Eaton, Jonathan, & Grossman, Gene (1986). Optimal Trade and Industrial Policy under Oligopoly. *The Quarterly Journal of Economics*, 383-406.

Friedman, James (1971). A Non-cooperative Equilibrium for Supergames. *The Review of Economic Studies*, 1-12.

Ghosh, Arghya, & Mitra, Manipushpak (2010). Comparing Bertrand and Cournot in mixed markets. *Economics Letters*, 72-74.

Goodman, Nelson. (1965). *Fact, Fiction, and Forecast* (2nd ed.). Indianapolis: Bobbs-Merrill.

Hausman, Daniel (1990). Supply and demand explanations and their ceteris paribus clauses. *Review of Political Economy*, *2*, 168-187.

Hausman, Daniel (1992). *The Inexact and Separate Science of Economics*. Cambridge: Cambridge University Press.

Hay, George and Werden, Gregory (1993). “Horizontal Mergers: Law, Policy, and Economics”, *Cornell Law Faculty Publications*. Paper 1147.

Hempel, Carl (1965). *Aspects of Scientific Explanation, and Other Essays in the Philosophy of Science.*. New York: Free Press.

Hempel, Carl (1966). *Philosophy of Natural Science*. Englewood Cliffs, N.J.: Prentice-Hall.

Lewis, Tracy, & McAfee, R. Preston (2012). 17.1 Cournot Oligopoly. Retrieved March 10, 2015, from http://2012books.lardbucket.org/books/beginning-economic-analysis/s18-01-cournot-oligopoly.html

Mackie, John Leslie (1965). Causes and Conditions. *American Philosophical Quarterly*, 245-264.

Mäki, Uskali (2009). "Models and truth: The functional decomposition approach", In: *EPSA Epistemology and Methodology of Science: Launch of the European Philosophy of Science Association*. M. Suarez, M. Dorato and M. Redei (eds), Dordrecht: Springer, 177-187.

Mäki, Uskali (2013) "On a paradox of truth, or how not to obscure the issue of whether explanatory models can be true", *Journal of Economic Methodology*. 20(3), 268-279.

Reiss, Julian (2013). *Philosophy of Economics: A Contemporary Introduction*. New York: Routledge.

Ross, William David (1949). *Aristotle* (5th ed.). London: Methuen & Co.

Salmon, Wesley (1984). *Scientific Explanation and the Causal Structure of the World*. Princeton, N.J.: Princeton University Press.

Suetens, Sigrid, & Potters, Jan (2007). Bertrand colludes more than Cournot. *Experimental Economics*, 71-77.

Sugden, Robert (2000). Credible Worlds: The Status Of Theoretical Models In Economics. *Journal of Economic Methodology*, p. 1-31.

Van Fraassen, Bas (1980). *The Scientific Image*. Oxford: Clarendon Press.

Wimsatt, William (1987). 1987; False Models as means to Truer Theories, in M. Nitecki, and A. Hoffman, eds., *Neutral Models in Biology*, London: Oxford University Press, 23-55.