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Exploring the Behavior of Economic Agents: the role of relative preferences

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Abstract

Standard economic theory assumes individuals choose actions that optimize their expected utility. In this paper we investigate how the existence of players with non−standard preferences may influence economic agents' behavior in some of the most frequently studied non−cooperative games. We find that allowing for the existence of agents with relative preferences can help explain observed economic actions which, at times, appear counter−intuitive.

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1. Introduction

In most economic models, individuals are assumed to be rational and maximize their expected utility. There is, however, increasing evidence that some agents' utility depends on both their own payoff and the payoffs of others. Therefore, an individual's satisfaction may depend on how much he receives relative to those in a reference group.

In this note we demonstrate how agents with this type of preferences (relative preferences) can affect the outcomes predicted by the standard Cournot and Stackelberg models. We show that the positive profits obtained by firms in the Cournot model disappear when both players have relative preferences, and overall profits decline when at least one player has relative preferences. Outcomes are also affected in the Stackelberg model. For example, the first mover advantage disappears when the second mover has relative preferences, and the competitive outcome is obtained when both have relative preferences. These results may help explain why industries with very few agents may appear to behave in a competitive fashion even though the traditional Cournot or Stackelberg games predict a different outcome.

The remainder of this note is developed as follows. In Section 2, we review evidence on the existence of relative preferences and discuss how they may help explain behavior in some industries. In Section 3, we examine how agents with relative preferences can influence the outcomes of Cournot and Stackelberg games, and Section 4 concludes.

2. Why Relative Preferences?

Although economic agents strive to maximize their expected utility, recent research indicates that individuals may care about how their payoffs compare to those of others and not just the level of their payoff[1]. Consequently, it is important to understand how differences in these preferences may affect observed economic behavior. Most of the existing work in this area has used surveys to investigate how individuals' satisfaction depends on relative versus absolute differences in factors such as income and wealth[2]. An interesting example is Solnik and Hemenway (1998) who ask a group of faculty, staff and graduate students to choose between two scenarios. In one they receive \$50,000 per year while everyone else gets \$25,000 whereas in the other they would earn \$100,000 per year but everyone else receives twice as much. Interestingly, even though nothing else differed across scenarios, most of the subjects preferred to earn less as long as their relative standing was higher.

Recognizing the existence of such relative preferences, several economists have tried to theoretically model these concepts. For example, in the fair-wage models of Akerlof (1982) and Akerlof and Yellen (1988, 1990), individuals have relative preferences and the level of their wages relative to others affects the amount of effort they supply. Similarly, Levine (1998) explores models where agents act cooperatively, but retaliate if they feel unfairly treated.

Although past work has characterized and identified the presence of individuals with relative preferences, little has been done to characterize their potential impact on the observed economic behavior of firms. It is not implausible for firms to behave as if they have relative preferences since executive compensation is based on a comparison of firm performance to the performance of other, similar firms. As a result, managers will focus their actions on improving

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[1] While the psychology literature provides the majority of studies investigating the individuals' preferences, theoretical studies like Samuelson (2004) are becoming more common in the economics literature.

[2] See e.g., Easterlin (1995), Duncan (1975), Neumark and Postlewaite (1993), and Solnik and Hemenway (1998).

the performance of their firm relative to a set of peer/competitor firms (for a nice discussion see Porac, Wade and Pollock (1999)). Consistent with this, there are many occasions on which we see this type of behavior. For example, many firms appear to maximize their market share at the expense of profits (e.g., North American car makers are currently offering significant incentives to try to maintain market share at the expense of profitability).

Below, we illustrate how incorporating firms (economic agents) with these preferences into our models can impact economic outcomes. By using relative preferences our results help explain why we observe some firms making choices which result in losses for them and their competitors even when it is clear that the losses are unlikely to drive the competitors out of the market or change their behavior.

3. Impact of Relative Preferences

We explore how agents with relative preferences may affect behavior in the Cournot and Stackelberg models of inter-firm competition. In all cases, we assume players (firms) make choices to maximize their expected payoff. We consider the following cases: 1) both players are profit-maximizing (the standard case), 2) both players maximize relative standing (have relative preferences), and 3) the case in which the players are different types[3]. In our models, the per-unit cost of production is $c>0$, the price of production falls as output increases and the price function is differentiable (i.e., $p'(y_1+y_2)<0$ where y_i is the output of player i).

3.1. Cournot Model of Inter-firm Competition

The first model we consider is the Cournot model of inter-firm competition. In the benchmark case (Case 1), both players are profit-maximizers. Let y_1 be the output produced by player 1 and y_2 be the output produced by player 1's competitor[4]. Player 1's reaction function, $p'(y_1 + y_2)y_1 + p(y_1 + y_2) - c = 0$, is given by the first order necessary condition (FONC) of the problem: $\max_{y_1} \; p(y_1 + y_2)y_1 - cy_1$. Similarly, the reaction function for player 2 is $p'(y_1 + y_2)y_2 + p(y_1 + y_2) - c = 0$. Together these equations give the standard result that both firms produce equal amounts, $y_1 = y_2$, and each makes a positive profit of $p(2y_1)y_1 - cy_1$.

In the second case we consider, both players have relative preferences so the objective functions take into account that each player cares about how their profits compare to their opponent's. As a result, each player's reaction function is determined by solving the corresponding version of this problem:

$$\max_{y_1} \; [p(y_1 + y_2)y_1 - cy_1] - [p(y_1+y_2)y_2 - cy_2]$$

This implies that the FONCs for player 1 are $p'(y_1 + y_2)(y_1 - y_2) + p(y_1 + y_2) - c = 0$, and $p'(y_1 + y_2)(y_2 - y_1) + p(y_1 + y_2) - c = 0$ for player 2. Therefore, $y_1 = y_2$ and $p(2y_1) = c$ in equilibrium, and neither firm makes a profit because the competitive outcome is achieved.

In Case 3, we start by assuming that the players have opposite preferences, so we assume that player 1 maximizes profits, while player 2 has relative preferences. Consequently player 1's reaction function is the same as in Case 1, $p'(y_1 + y_2)y_1 + p(y_1 + y_2) - c = 0$, and player 2's

[3] This third case is consistent with results we obtained through survey evidence and Solnik and Hemenway's (1998) finding that between 20%-50% of individuals may have relative preferences so we may have situations in which there are players with different preferences.

[4] Note: although we only use two players, the results can be generalized to the case where there are n players.

reaction function is $p'(y_1 + y_2)(y_2 - y_1) + p(y_1 + y_2) - c = 0$ (as in Case 2). Combining these functions shows $y_1 = \frac{1}{2}y_2$, i.e., player 2 (with relative preferences) produces twice as much as player 1 (the profit-maximizer). Each firm makes positive profits since $p(3y_2) = c - p'(3y_2)y_2/2 > c$, but player 1's profits are smaller than player 2's. This means player 1 will get less than when both players have standard preferences. As a result, as player 1 believes it is more likely their opponent is playing with relative preferences the more likely it is that player 1 will choose a more aggressive strategy.

3.2. Stackelberg Model of Inter-firm Competition

For the Stackelberg model, the first player moves in advance of the second. We consider four cases where the players either maximize profits or their relative standing. In the standard case (Case 1), both players maximize profits and the second player faces the following problem, taking player 1's actions as given:

$$\max_{y_2} \; p(y_1 + y_2)y_2 - cy_2$$

The FONC for this problem, $p'(y_1 + y_2)y_2 + p(y_1 + y_2) - c = 0$, allows us to express player 2's output as a function of player 1's output, $y_2 = f(y_1)$. Knowing this relationship, player 1 then chooses how much to produce by solving the following problem:

$$\max_{y_1} \; p(y_1 + f(y_1))y_1 - cy_1$$

which implies: $p'(y_1 + f(y_1))[\,1 + f'(y_1)]y_1 + p(y_1 + y_2) = c$. Combining this expression with the second player's FONC gives: $y_2 = [1 + f'(y_1)]y_1$. It follows that firms make positive profits and, if $f'(y_1) < 0$, we get the standard result that there is a first mover advantage with the first player's payoff being higher than the second player's, $y_2 < y_1$.

In the second case (Case 2), both players have relative preferences. Similar to Case 1, the second player takes player 1's actions as given. However, now the second player's problem becomes:

$$\max_{y_2} \; [p(y_1 + y_2)y_2 - cy_2] - [p(y_1 + y_2)y_1 - cy_1]$$

The resulting FONC, $p'(y_1 + y_2)(y_2 - y_1) + p(y_1 + y_2) - c = 0$, again gives the relationship between the second player's output and the first player's output, (i.e., $y_2 = f(y_1)$). Player 1 takes this relationship into account when choosing his profit-maximizing level of output:

$$\max_{y_1} \; [p(y_1 + f(y_1))y_1 - cy_1] - [p(y_1 + f(y_1))f(y_1) - cf(y_1)]$$

Combining the FONC, $p'(y_1 + f(y_1))[\,1 + f'(y_1)]\,(y_1 - f(y_1)) + (\,p(y_1 + y_2) - c)\,(1 - f'(y_1)) = 0$, with player 2's FONC gives the result $y_2 = y_1$. Unlike Case 1, there is no first mover advantage when both players have relative preferences. Furthermore, the competitive solution is achieved and neither player earns positive profits since $y_2 = y_1$, and $p(y_1 + y_2) = c$. Intuitively, this occurs because players with relative preferences only care about their position relative to their competitors. Consequently if the first mover tried to produce a lot to generate more profits than his competitor, the second mover would not be deterred from producing a large quantity since: 1) he wants to minimize the distance between his profits and player 1's, and 2) he knows that the first mover's profits will fall as he produces more. Consequently, when both have relative preferences neither firm ends up making a positive profit in equilibrium.

Case 3, where player 1 has profit-maximizing preferences and player 2 has relative preferences, the outcome can be seen to be the reverse of Case 1. Therefore in this case we would observe a second mover advantage (as opposed to the first mover advantage in Case 1).

In the last Case we consider (Case 4), the first mover has relative preferences, while the second mover is a profit-maximizer. Here, player 2 faces the same problem as in Case 1, and the FONC, $p'(y_1 + y_2)y_2 + p(y_1 + y_2) - c = 0$, gives player 2's reaction function, $y_2 = f(y_1)$. Player 1 recognizes this when he chooses how much to produce. Specifically he maximizes:

$$\max_{y_1} \; [\, p(y_1 + f(y_1))y_1 - cy_1] - [p(y_1 + f(y_1))f(y_1) - cf(y_1)]$$

which implies:

$$p'(y_1 + f(y_1))[1 + f'(y_1)](y_1 - f(y_1)) + (p(y_1 + y_2) - c)(1 - f'(y_1)) = 0$$

Combining this expression with player 2's FONC, we find that $y_1 = 2y_2 / [1 + f'(y_1)]$. Thus, there is a first mover advantage ($y_1 > y_2$) as long as $f'(y_1) + 1 < 2$. This occurs because: 1) player 2 only cares about his profit, and 2) player 1 knows that as he produces more, player 2 will produce less to keep his profit level up.

We have solved the above problems assuming that the players know one another's types. However, this may not be the case in general. Under uncertainty an individual will assign probabilities to what kind of agent he is facing and maximize the corresponding expected profits. Based on the results from the cases described above we can draw some inferences about the behavior of agents in this case. For example, contrary to the Cournot case, our results for the Stackelberg model indicate that player 1's behavior will become less aggressive (i.e., submitting smaller quantities) as his belief that player 2 has relative preferences increases.

3.3. An Example:

To more clearly illustrate how the presence of agents with relative preferences can affect the outcome of different economic situations, we evaluate each of the above cases using the pricing function: $p(y_1 + y_2) = A - (y_1 + y_2)$. Table 1 reports, in each case, the quantity each player produces, the associated profits, and each player's payoff (given their preferences and that each player knows the type of the player they are facing).

In the Cournot case, we see that: 1) the presence of a competitor with relative preferences decreases the profits earned by profit-maximizers and decreases the overall profits for both players (Case 3), and 2) profits completely disappear when both players have relative preferences (Case 2). Consequently, the results are much closer to the competitive outcome when there is at least one player with relative preferences.

For the Stackelberg case, we see that profits are driven to zero when both players have relative preferences (Case 2). When only the second player has relative preferences (Case 3), profits are positive, but now player 2 has a second mover advantage and earns profits significantly higher than player 1's - in fact, the quantities and profits in Case 3 are exactly opposite those in Case 1 where player 1 has the first mover advantage. Finally, in Case 4 the fact that player 1 has relative preferences causes his profits to be four times larger than the profits of player 2 (instead of only twice as large as in Case 1). Here, the first mover forgoes earning a higher profit (i.e., $(A - c)^2 / 8$ as in Case 1 in favor of profits of $(A - c)^2 / 9$), because by producing more, he hurts his opponent's profits more than his own which maximizes the difference between his profits and his opponent's.

While none of the profits in our example are negative, this was, at least partially, due to our choice of cost function. If we were to assume there are both variable and fixed costs of production, the results could change. For example, if profits were given by $\pi = p(y_i + y_{-i})y_i - cy_i - \varphi$ for all players, the quantities produced would be the same as reported in Table 1 but the profits would be decreased by the size of the fixed cost, φ, (unless fixed costs are high enough to induce profit maximizing agents not to produce). As a result, negative profits *can* be the optimal outcome in cases where both players had relative preferences and φ is large enough[5]. Moreover, since individuals with relative preference focus on their relative profits as opposed to the absolute profit levels, they may be willing to continue to play while incurring negative profits with uncertain perspectives for future profits (e.g., incur sustained losses as in the airline industry) provided they are able to finance these losses.

4. Conclusions

An increasing amount of evidence suggests that all individuals do not behave according to standard preferences. In this note we examine how the predictions of Cournot and Stackelberg games can be affected by the presence of agents who have relative preferences. In this environment the payoff of agents with relative preferences is determined by the magnitude of the difference between his profit and his opponent's - not the absolute value of his profit as in most standard models. Our results may help explain why firms are frequently willing to continue to lose money in certain markets and why outcomes in markets with a small number of firms may appear competitive even though standard Cournot and Stackelberg games suggest this should not occur.

[5] Profit-maximizing players may be hesitant to continue under such circumstances, but there is evidence that some players react to the behavior of their competitors by adopting similar preferences in subsequent periods (e.g. "tit-for-tat" strategies) or retaliating. Consequently both may eventually play according to relative preferences and thus continue to participate by focusing on payoffs rather than profits leading to the outcomes described above.

Table 1a) Theoretical Outcomes for the Cournot Example with Agents having different preferences:

	Case 1		Case 2		Case 3	
Player	1	2	1	2	1	2
Quantity	$\frac{(A-c)}{3}$	$\frac{(A-c)}{3}$	$\frac{(A-c)}{2}$	$\frac{(A-c)}{2}$	$\frac{(A-c)}{4}$	$\frac{(A-c)}{4}$
Profits	$\frac{(A-c)^2}{9}$	$\frac{(A-c)^2}{9}$	0	0	$\frac{(A-c)^2}{16}$	$\frac{(A-c)^2}{8}$
Payoff	$\frac{(A-c)^2}{9}$	$\frac{(A-c)^2}{9}$	0	0	$\frac{(A-c)^2}{16}$	$\frac{(A-c)^2}{8}$

Table 1b) Theoretical Outcomes for the Stackelberg Example with Agents having different preferences:

	Case 1		Case 2		Case 3		Case 4	
Player	1	2	1	2	1	2	1	2
Quantity	$\frac{(A-c)}{2}$	$\frac{(A-c)}{4}$	$\frac{(A-c)}{2}$	$\frac{(A-c)}{2}$	$\frac{(A-c)}{4}$	$\frac{(A-c)}{2}$	$\frac{2(A-c)}{3}$	$\frac{(A-c)}{6}$
Profits	$\frac{(A-c)^2}{8}$	$\frac{(A-c)^2}{16}$	0	0	$\frac{(A-c)^2}{16}$	$\frac{(A-c)^2}{8}$	$\frac{(A-c)^2}{9}$	$\frac{(A-c)^2}{36}$
Payoff	$\frac{(A-c)^2}{8}$	$\frac{(A-c)^2}{16}$	0	0	$\frac{(A-c)^2}{16}$	$\frac{(A-c)^2}{16}$	$\frac{(A-c)^2}{12}$	$\frac{(A-c)^2}{36}$

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