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Price and quality competition in the **restaurant industry**: effects of restaurants' reputation

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Abstract | This paper considers a quality and price competition between two asymmetric restaurants, by establishing a two-stage dynamic game model. We find that the restaurant with the most reputation offers more food with a higher quality than its rival. We also analyse the effects of the difference of restaurants' reputation on the market equilibrium outcomes. We show that the increase in the reputation difference between restaurants decreases profits of the small restaurant and raises profits of the large restaurant, consumer surplus and social welfare.

Furthermore, compared with the case under quantity competition instead of price, social welfare is higher under price competition, while the opposite holds for small restaurant's profits. However, the relationship of large restaurant's profits is ambiguous.

Keywords | Game theory, Bertrand model, Cournot model, food industry

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1. Introduction and theoretical framework

In this paper, we consider a market with just two restaurants, that compete with each other through their choices of price and quality. A market with just two firms is called a duopoly. The most fundamental duopoly models used in the literature on strategic interactions among firms were introduced by Cournot (1838) and Bertrand (1883). Under Cournot competition, the firms decide on quantities, whereas under Bertrand competition, the firms decide on prices. From the vast literature on the theory of strategic interactions among firms, we know that social welfare is higher under Bertrand competition than under Cournot competition.

Price, quantity and quality are main factors that should be take into account by industrial managers (see, for instance, (Lambertini & Tampieri, 2017)). Kurokawa and Matsubayashi (2018) explored price and quality competition between two firms, with quality positions based on a vertical differentiation model, where the firms have given quality positions and must incur repositioning costs that are convexly proportional to the difference between the quality positions and the product quality levels they set. By analyzing this model, they obtained insights into the competitive effects of these factors.

Luca and Reshef (2020) studied the impact of price on firm reputation, as measured by its online ratings. Their results are consistent with the cross-sectional evidence and suggest that higher prices are in fact affecting a restaurant's reputation. Reputation is an important issue also in hotel management, as was analysed by Mariño-Romero et al. (2017).

Food has been recognized as a significant component of tourism activity. Gastronomic experiences are becoming more and more a focus for travelers. According to The Second Global Report on Gastronomy Tourism (UNWTO, 2017), "Food tourism is a cross-cutting segment incorporating various economic sectors: Depending on the person, and the motivation behind the trip, culinary expectations can vary. Moreover, it is difficult to identify a food tourist, as many of their interests overlap with those of conventional tourists." Furthermore, "Food tourism is a catalyst for the local economy: food tourism provides the opportunity for job creation and the development of local economies, which in turn positively affects other sectors."

Food quality has had particular attention throughout all over the world, being one of the best means to maximize success in the restaurant business (see, for instance, (Baker & Crompton (2000) and Namkung & Jang (2007)). Consumers, particularly in developed countries, have become more demanding, more critical, and more fragmented in their food choices, leading to situations where quality differentiation of food products has become necessary to satisfy consumers. However, consumers purchase a product based on not only its quality level but also its price. So, food industry managers have to provide great importance to quality, not forgetting the reputation and price. The aim of this paper is to study price and quality competition in the restaurant industry. We employ a two-stage dynamic duopoly model, which is common in the industrial organization literature. First, both restaurants choose, simultaneously, their quality levels. Then, they choose prices. We also analyse the effects of reputation of restaurants on the equilibrium outputs. Good reputation is a valuable asset that permits a firm to reach persistent profitability or sustained high financial performance; and a firm with a good reputation may retain a cost advantage because, ceteris paribus, employees wish to work for high-reputation firms (Roberts & Dowling, 2002). Furthermore, we also compare our results, for the Bertrand competition, with the ones got by Chen et al. (2018) for the Cournot competition. Comparisons between Cournot and Bertrand models attract the attention of several researchers (see, for instance, Ferreira & Ferreira, 2018).

Nie and Chen (2014) considered an oligopoly model in the food industry, in which there exists no difference between the firms' products, and firms compete, simultaneously, at quantity. They showed that each firm's outputs and the price of food decrease with the number of firms. Furthermore, each firm's profits also decrease with the number of firms, but the social welfare increases with the number of firms.

Yang and Nie (2016) analysed the effects of asymmetric competition on food industry with product substitutability by establishing a two-stage dynamic game model. The equilibrium is captured under both the Cournot competition and Stackelberg competition.

Chen and Nie (2016) analysed a mixed duopoly competition in food industry, with one profit-maximizing firm and one firm that integrates corporate social responsibility in its objective function. In their model, firms choose, first, the quality level of the products, and then the quantities. In each stage of the game, firms take their corresponding decisions simultaneously. These authors showed that corporate social responsibility improves both the quality and the quantity of the food for the corporate social responsibility firm, while it reduces those for the profit-maximizing firm. Chen et al. (2016) examined the spillover effects of corporate social responsibility in a duopoly model, by considering both simultaneous and sequential move possibilities.

A review of past research on restaurant management reveals that the factors driving customers' choice of restaurant are price, food, variety, reputation, promotion, location, and information sources (see Chua et al., 2020) and references therein). In the study made by Chua et al. (2020), they conclude that the importance of menu price was greatest for both quick meal/convenience and social occasion, and brand reputation was the most important factor for business necessity.

Some literature study models in which price is used to signal product quality. For instance, Zhao et al. (2017) explored the issue of pricing strategies between two firms producing horizontally and vertically differentiated foods in the context of asymmetric information and scientific uncertainty (Bagwell & Riordan, 1991; Daughety & Reinganum, 1995).

The remained of the paper is organized as follows. In Section 2, we present the methods and describe the model. Section 3 yields the main results of the Bertrand model, including comparative static analysis and comparisons between Bertrand model and Cournot model. Conclusions are presented in Section 4.

2. Methods

In this paper, we analyse a market composed of two asymmetric restaurants that compete, non-cooperatively, on both quality and prices. The aim is two-fold: the first is to compute the decisions that give higher profits; and the second is to study the effects of the difference of restaurants' reputation. The proposed methodology consists in modeling the non-cooperative competition using game theory concepts.

Game Theory aims to help us understand situations in which decision-makers interact. Game Theory is a formal, mathematical discipline which studies situations of competition and cooperation between several involved parties. This theory was initially developed as a tool to understand economic behavior (Gibbons, 1992). Game theory was established as a field in its own right after the publication of the monumental volume Theory of Games and Economic Behavior, in 1944, by the mathematician von Neumann and the economist Oskar Morgenstern. This book provided much of the basic terminology and problem setup that is still in use today. A game consists of: (i) a set of players; (ii) for each player, a set of actions; and

(iii) for each player, preferences over the set of actions. An important component in game theory is the rational choice: A decision-maker (player) chooses the best action according to his preferences, among all the actions available to him/her. As to preferences, we assume that the decision-maker, when presented with any pair of actions, knows which of the pair he/she prefers, or knows that he regards both actions as equally desirable (in which case he is "indifferent between the actions"). Usually, we represent the preferences by a payoff function, which associates a number with each action in such a way that actions with higher numbers are preferred.

The game that we will use here is a game of complete information, which means that the players' payoff functions are common knowledge. The usual solution concept in a game of complete information is the Nash equilibrium. A decision combination is a Nash equilibrium when, if one player sticks rigidly to his decision in the combination, then the other player cannot increase his reward by selecting other than his/her decision in that combination. That is, each player's strategy must be a best response to the other player's strategies.

So, we consider that there are only two restaurants – a small restaurant R_1 and a large restaurant R_2 – in the market. Both restaurants compete with each other through their choices of price and quality.

We follow the market structure of Chen et al. (2018), but by considering that at the second stage, restaurants choose prices instead of quantities. The representative consumer maximize $U(q_i, x_i) - p_1 q_1 - p_2 q_2$ where q_i is the quantity offered by restaurant R_i, x_i is the quality associated with restaurant R_i, and p_i is its price, with i=1,2. The function U, that depends on both quantity and quality, is defined by

$$U(q_i, x_i) = (\alpha + \beta x_1)q_1 + (\alpha + (\beta + \tau)x_2)q_2 \\ -\frac{1}{2}(q_1^2 + q_2^2) - \gamma q_1 q_2,$$

where α is a positive constant, β represents the basic reputation, τ is the reputation difference between the two restaurants, and γ measures the degree of products substitutability of the two restaurants, with i=1,2. For simplicity, we fix the reputation parameter of the small restaurant equal to 5/2, and we assume γ =1/2. Thus, we focus our attention on the difference of the reputations. The function U can now be rewritten as

$$U(q_i, x_i) = \left(\alpha + \frac{5}{2}x_1\right)q_1 + \left(\alpha + \left(\frac{5}{2} + \tau\right)x_2\right)q_2 \\ -\frac{1}{2}(q_1^2 + q_2^2) - \frac{1}{2}q_1 q_2.$$

So, the inverse demand functions of the two restaurants are given by

$$p_1 = \alpha + \frac{5}{2}x_1 - q_1 - \frac{1}{2}q_2,$$

$$p_2 = \alpha + \left(\frac{5}{2} + \tau\right)x_2 - \frac{1}{2}q_1 - q_2.$$

Then, the direct demand functions are given by

$$q_1 = \frac{2}{3}\alpha + \frac{10}{3}x_1 - \frac{(5+2\tau)}{3}x_2 - \frac{4}{3}p_1 + \frac{2}{3}p_2,$$

$$q_2 = \frac{2}{3}\alpha - \frac{5}{3}x_1 + \frac{2(5+2\tau)}{3}x_2 + \frac{2}{3}p_1 - \frac{4}{3}p_2.$$

We assume the total costs of both small and large restaurants as a function of quantity and quality, defined by

$$C_i = \frac{1}{2}q_i^2 + \frac{1}{2}x_i^2 + q_i x_i,$$

i=1,2. The first and second terms represent the investment costs in quantity and quality, respectively; and the last term represents the interaction of quantity and quality investment. So, the profit π_1 of the small restaurant is given by

$$\pi_1 = \left(\alpha + \frac{5}{2}x_1 - q_1 - \frac{1}{2}q_2\right)q_1 - \frac{1}{2}q_1^2 - -\frac{1}{2}x_1^2 - q_1 x_1$$

and the profit π_2 of the large restaurant is given by

$$\pi_2 = \left(\alpha + \left(\frac{5}{2} + \tau\right)x_2 - \frac{1}{2}q_1 - q_2\right)q_2 - \frac{1}{2}q_2^2 - \frac{1}{2}x_2^2 - q_2 x_2,$$

Social welfare W is defined by

$$W = CS + \pi_1 + \pi_2,$$

where

$$CS = \frac{1}{2}(q_1^2 + q_2^2) + \frac{1}{2}q_1 q_2$$

is the consumer surplus.

The model is constructed by the following two-stages game:

- In the first stage, both restaurants choose, simultaneously, their quality levels x_1 and x_2;
- In the second stage, both restaurants choose, simultaneously, the food prices p_1 and p_2.

3. Results

In this section, we will analyse the model described above. To obtain a subgame perfect equilibrium, we will solve the game by backwards induction. Starting from the last stage, each restaurant R_i solves the optimization problem $max_{p_i}\pi_i$. By solving the equations

$$\begin{cases} \dfrac{\partial \pi_1}{\partial p_1} = 0 \\ \dfrac{\partial \pi_2}{\partial p_2} = 0, \end{cases}$$

we get:

$$p_1 = \frac{126\alpha + 465x_1 - 14(3+2\tau)x_2}{234} \quad (1)$$

and

$$p_2 = \frac{126\alpha - 42x_1 + (465+154\tau)x_2}{234} \quad (2)$$

Putting these results into π_1 and π_2, and solving, simultaneously,

$$\begin{cases} \dfrac{\partial \pi_1}{\partial x_1} = 0 \\ \dfrac{\partial \pi_2}{\partial x_2} = 0, \end{cases}$$

we get the following quality levels at equilibrium[1,2]

$$x_1^* = \frac{220\alpha(63 - 1320\tau - 440\tau^2)}{9(1239 - 14520\tau - 4840\tau^2)}$$

and

$$x_2^* = \frac{1540\alpha(3+2\tau}{3(1239 - 14520\tau - 4840\tau^2)}$$

Putting these results into (1) and (2), we get the following prices at equilibrium:

$$p_1^* = \frac{68\alpha(63 - 1320\tau - 440\tau^2)}{9(1239 - 14520\tau - 4840\tau^2)}$$

and

$$p_2^* = \frac{7\alpha(1479 + 440\tau)}{3(1239 - 14520\tau - 4840\tau^2)}$$

Then, the food quantities are given by

$$q_1^* = \frac{52\alpha(63 - 1320\tau - 440\tau^2}{3(1239 - 14520\tau - 4840\tau^2}$$

and

$$q_2^* = \frac{1092\alpha}{1239 - 14520\tau - 4840\tau^2}$$

The resulting equilibrium profits are:

$$\pi_1^* = \alpha^2\left(\frac{6220}{9801} - \frac{4528160(483 - 7260\tau - 2420\tau^2}{3267(1239 - 14520\tau - 4840\tau^2)^2}\right)$$

and

$$\pi_2^* = \frac{980\alpha^2(2799 - 14520\tau - 4840\tau^2)}{9(1239 - 14520\tau - 4840\tau^2)^2}$$

It is straightforward to obtain the following conclusion:

Proposition 1. At equilibrium, the large restaurant offers more food with a higher quality than its rival. Moreover, the large restaurant earns higher profits than the small restaurant.

Furthermore, consumer surplus CS and social welfare W are, respectively, given by

[1] In order to ensure $x_i > 0$, we assume $0 < \tau < \frac{(9\sqrt{1430}-330)}{220}$

[2] Throughout the paper, we use the superscript * to refer to the equilibrium outputs.

$$CS^* = \alpha^2\left(\frac{1352}{1089} - \frac{18928(2247 - 137940\tau - 45980\tau^2)}{363(1239 - 14520\tau - 4840\tau^2)^2}\right)$$

and

$$W^* = \alpha^2\left(\frac{18388}{9801} - \frac{28(56220213 - 1828837560\tau - 609612520\tau^2)}{3267(1239 - 14520\tau - 4840\tau^2)^2}\right).$$

From Proposition 1, we conclude that large restaurants have some advantages over small restaurants. Moreover, costumers that care about food quality also prefer large restaurants.

Comparative static analysis

In this section, we evaluate the effects of the reputation difference between restaurants on the different outputs at equilibrium. From the results presented above, we get:

$$\frac{\partial x_1^*}{\partial \tau} = -\frac{17617600\alpha(3 + 2\tau)}{3(1239 - 14520\tau - 4840\tau^2)^2} < 0$$

$$\frac{\partial x_2^*}{\partial \tau} = \frac{3080\alpha(23019 + 14520\tau + 4840\tau^2)}{3(1239 - 14520\tau - 4840\tau^2)^2} > 0$$

$$\frac{\partial (x_1^* + x_2^*)}{\partial \tau} = \frac{3080\alpha(5859 - 3080\tau - 4840\tau^2)}{3(1239 - 14520\tau - 4840\tau^2)^2} > 0$$

$$\frac{\partial q_1^*}{\partial \tau} = -\frac{4164160\alpha(3 + 2\tau)}{(1239 - 14520\tau - 4840\tau^2)^2} < 0$$

$$\frac{\partial q_2^*}{\partial \tau} = \frac{5285280\alpha(3 + 2\tau)}{(1239 - 14520\tau - 4840\tau^2)^2} > 0$$

$$\frac{\partial (q_1^* + q_2^*)}{\partial \tau} = \frac{1121120\alpha(3 + 2\tau)}{(1239 - 14520\tau - 4840\tau^2)^2} > 0$$

$$\frac{\partial p_1^*}{\partial \tau} = -\frac{39479440\alpha(3 + 2\tau)}{3(1239 - 14520\tau - 4840\tau^2)^2} < 0$$

$$\frac{\partial p_2^*}{\partial \tau} = \frac{6160\alpha(25023 + 16269\tau + 2420\tau^2)}{3(1239 - 14520\tau - 4840\tau^2)^2} > 0$$

$$\frac{\partial \pi_1^*}{\partial \tau} = -\frac{996195200\alpha^2(189 - 3834\tau - 3960\tau^2 - 880\tau^3)}{27(1239 - 14520\tau - 4840\tau^2)^3} < 0$$

$$\frac{\partial \pi_2^*}{\partial \tau} = \frac{4743200\alpha^2(3 + 2\tau)(4359 - 14520\tau - 4840\tau^2)}{9(1239 - 14520\tau - 4840\tau^2)^3} > 0$$

$$\frac{\partial CS^*}{\partial \tau} = \frac{4164160\alpha^2(3969 + 77886\tau + 75240\tau^2 + 16720\tau^3)}{3(1239 - 14520\tau - 4840\tau^2)^3} > 0$$

$$\frac{\partial W^*}{\partial \tau} = \frac{12320\alpha^2(11895093 + 506703942\tau + 498773880\tau^2 + 110838640\tau^3)}{27(1239 - 14520\tau - 4840\tau^2)^3} > 0$$

Thus, we can establish one of the main results of this paper.

Proposition 2. *a)* The increase in the difference of restaurants' reputation reduces the quality and output of the small restaurant and increases the quality and output of of the large restaurant. The overall effect is an increase in the total quality and in the aggregate quantity in the market.
b) The increase in the difference of restaurants' reputation decreases prices of the small restaurant and raises prices of the large restaurant.
c) The increase in the difference of restaurants' reputation decreases profits of the small restaurant, and raises profits of the large restaurant, consumer surplus and social welfare.

Proposition 2 shows that the restaurants' reputation has great impact in the outcomes of the restaurants, so they have to consider the reputation as an important aspect of their market position.

Comparisons with quantity competition

In this section, we will compare our results with the ones got by Chen et al. (2018) in the Cournot model (quantity competition). From their paper, we get the following outputs at equilibrium[3]:

$$x_1^{C^*}=\frac{108\alpha(13-216\tau-72\tau^2)}{1079-10368\tau-3456\tau^2} \text{ and } x_2^{C^*}=\frac{468\alpha(3+2\tau)}{1079-10368\tau-3456\tau^2},$$
$$q_1^{C^*}=\frac{70\alpha(13-216\tau-72\tau^2)}{1079-10368\tau-3456\tau^2} \text{ and } q_2^{C^*}=\frac{910\alpha}{1079-10368\tau-3456\tau^2}.$$

Furthermore

$$\pi_1^{C^*}=\frac{1518\alpha^2(13-216\tau-72\tau^2)^2}{(1079-10368\tau-3456\tau^2)^2} \text{ and } \pi_2^{C^*}=\frac{1014\alpha^2(253-1296\tau-432\tau^2)}{(1079-10368\tau-3456\tau^2)^2},$$
$$CS^{C^*}=\frac{7350\alpha^2(169-2808\tau+14616\tau^2+10368\tau^3+1728\tau^4)^2}{(1079-10368\tau-3456\tau^2)^2}$$

and

$$W^{C^*}=\frac{18\alpha^2(97513-1693224\tau+9720648\tau^2+6856704\tau^3+1142784\tau^4)^2}{(1079-10368\tau-3456\tau^2)^2}.$$

We observe that from results above, we obtain that $\pi_1^{C*}<\pi_2^{C*}$. So, as in the price competition presented in Section 3, the large restaurant also earns higher profits than the small restaurant if restaurants decide on quantities instead of prices.

By comparing the output equilibrium of the price-setting game with the output equilibrium of the quantity-setting game, we get the following results:

Proposition 3. The equilibrium quality level of the small restaurant is higher under quantity competition than under price competition; for the large restaurant, the quality level is higher (resp., lower) under quantity competition for small (resp., slightly larger) differences of reputations' restaurants. The aggregate output in the market is highest when firms compete on prices. Furthermore, the large restaurant offers less food under quantity competition than under price competition; the small restaurant offers less (resp., more) food under quantity competition for small (resp., slightly larger) differences of reputations' restaurants.

Proof. The results follow from the fact that

$$x_1^{C^*}-x_1^*>0,\quad q_1^{C^*}-q_1^*\begin{cases}<0, \text{if } 0<\tau<\tau_1\\ >0, \text{if } \tau_1<\tau<\frac{(9\sqrt{1430}-330)}{220,}\end{cases}$$
$$x_2^{C^*}-x_2^*\begin{cases}>0, \text{if } 0<\tau<\tau_2\\ <0, \text{if } \tau_2<\tau<\frac{(9\sqrt{1430}-330)}{220,}\end{cases}\quad q_2^{C^*}-q_2^*<0,$$

where

$$\tau_1=\sqrt{\frac{2\sqrt{3152679091}+955583}{368280}}-\frac{3}{2} \text{ and}$$
$$\tau_2=\frac{2\sqrt{542256495}-46035}{30690}.$$

Proposition 3 shows that quantity and quality of the food provided by each restaurant can be either higher or lower in quality than in price competition, depending on the differences of reputations' restaurants.

Proposition 4. The small restaurant's profits are higher under quantity competition than under price competition; The large restaurant's profits are higher (resp., lower) under quantity competition than under price competition, for small (resp., slightly larger) differences of reputations' restaurants.

Proof. The results follow from the fact that

$$\pi_1^{C*}-\pi_1^*>0,$$

$$\pi_1^{C^*}-\pi_1^*>0,\quad \pi_2^{C^*}-\pi_2^*\begin{cases}>0, \text{if } 0<\tau<\tau_3\\ <0, \text{if } \tau_3<\tau<\frac{(9\sqrt{1430}-330)}{220,}\end{cases}$$

where $0.0196<\tau_3<0.0197$ is such that $f(\tau_3)=0$, with

$$f(\tau_3)=17850678912000\tau^6+160656110208000\tau^5+$$
$$465351820165440\tau^4+382269267872640\tau^3-$$
$$145666653182704\tau^2+11645822833008\tau-$$
$$175435378209.$$

From Proposition 4, we conclude that the small restaurants prefer quantity competition instead of price competition. However, the large restaurants' preference depend on the difference of reputations' restaurants.

[3] Throughout the paper, we use the superscript C to refer to the Cournot model.

Proposition 5. Consumer surplus as well as social welfare are higher under Bertrand than under Cournot competition.

Proof. The results follow from the fact that

$$CS^{C*} - CS^{*} < 0, W^{C*} - W^{*} < 0.$$

Proposition 5 shows that under a social point of view, price competition is better than quantity competition.

4. Conclusions

This paper considers a duopoly model where two asymmetric restaurants compete on both quality and prices. The dynamics of market competition have been assumed to be in two stages: quality at the 1st stage, followed by competition in prices at the 2nd stage. We computed the different outputs of the model at equilibrium, and we analysed the effects of the difference of restaurants' reputation. We proved that the increase in the reputation difference between restaurants reduces profits of the small restaurant and raises profits of the large restaurant and also raises social welfare.

Furthermore, we did a comparison between Bertrand and Cournot models (i.e., price and quantity competitions). The quality level of the small restaurant is higher under quantity competition than under price competition, while it is ambiguous for the large restaurant. The high quality of the food provided by small restaurants can be a consequence of the fact that they focus on offering some dishes, which is a specialisation strategy leading to high quality and reduced quantity. The large restaurant offers less food under quantity competition than under price competition, while it is ambiguous for the small restaurant. Furthermore, the small restaurant's profits are higher under quantity competition than under price competition, while it is ambiguous for the large restaurant. We also showed that social welfare is higher under price competition than under quantity competition.

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