Daily Life Economics (2023). “Kayaking Duopoly: A Sequential Game Theory Case Study”, Available at https://dailylifeecon.com/case-studies/

# Kayaking Duopoly: A Sequential Game Theory Case Study

Daily Life Econ
https://dailylifeecon.com/
@dailylifeecon reel

**Key concepts**: Duopoly; game theory; static and dynamic games; Nash equilibria.

On a beach in Spain, there are two villages connected by a beach. When the tide is low you can cross from one village (Noja) to the other (Isla) walking, however, when the tide is high the only way around is a very long walk. There is another possibility to cross, but it is not available for everyone. A hotel in Isla offers to cross their guest for free at high tide, however, if you are not a hotel guest then you have to pay a price.

Currently, the hotel has the monopoly[1] of boat crossing between the two villages when the tide is high. On a sunny day, at high tide, a woman is seeking passage from Noja to Isla, however, she doesn’t have enough money to pay for the hotel boat and the other option to cross is a very long walk. The woman spots a family who owns a kayak, she approaches them and asks whether they could give her a ride to Isla. The family’s father kindly agrees to use his kayak to help her pass to Isla.

While in the boat the father has an entrepreneurial idea - the father envisions offering transportation services to non-hotel guests, potentially challenging the hotel boat's monopoly. The woman, mentions the consistent demand for such a service over the summer, explaining that many non-hotel guests face similar situations and the tide is high every day. The woman reveals that the hotel boat charges a specific fee for the ride, highlighting an opportunity for competition. This means that, if the father decides to open a new business and start crossing people from Noja to Isla for specific monetary fee, then it will create competition with the hotel boat, forming what

[1] A monopoly is a market structure in which a single seller or producer dominates an entire industry or sector, effectively controlling the supply of a particular product or service. In a monopoly, there are no close substitutes, and the monopolist has significant pricing power, allowing it to set prices and quantities without facing competition. Monopolies often result in limited consumer choice and can lead to higher prices and reduced innovation unless regulated by antitrust laws or government intervention.

is called a Duopoly. Duopoly competition is a market structure characterized by the presence of only two dominant firms or players that largely control an entire industry or sector. These two firms compete for market share and customers. In a duopoly, the actions, and decisions of one firm directly influence the strategies and decisions of the other, leading to interdependence[2].

There are two main players in this competition game: (1) the father with the Kayak – potential new entrant; (2) the hotel boat – which currently monopolizes the market. This scenario represents a sequential game, where each player's decision depends on the actions of the previous player. The father must make a strategic choice: whether to enter the market and compete with the hotel boat. The woman's insights into demand and her willingness to pay are vital factors affecting his decision.

Let's analyze the sequential game between the father with the kayak (potential new entrant) and the hotel boat (monopoly) in the context of offering transportation services across the beach from Noja to Isla during high tide.

Assume, the hotel boat currently charges a fee of €20 for non-guests to cross from Noja to Isla during high tide. The cost to the father for each kayak trip (including maintenance, time, and equipment) is €2 per passenger with a daily fixed cost of €5[3]. Assume also that the average daily number of non-hotel guests who want to cross on a high tide is 16 people.

Should the father, who has nothing better to do, enter the market and offer transportation services to non-hotel guests during high tide? What do you think is the maximum price the father can charge for his kayak service and still attract customers

[2] Duopolies are a common form of market structure in industries such as telecommunications and automotive manufacturing.
[3] Fixed costs are expenses in a business that do not change with the level of production or sales. These costs remain constant regardless of how much a company produces or sells. Examples of fixed costs include rent or lease payments for facilities, salaries of permanent staff, insurance premiums, and certain types of equipment depreciation. Fixed costs are incurred even if a company produces nothing, and they do not vary with short-term fluctuations in business activity. Variable costs are expenses that fluctuate in direct proportion to the level of production or sales. These costs increase as production or sales volume rises and decrease as production or sales volume decreases. Common examples of variable costs include raw materials, direct labour costs, packaging materials, and commissions based on sales. Variable costs are tied to the company's operations and can change from one production cycle to the next.

away from the hotel boat? How much profit can the father potentially earn if he decides to enter the market and set a price for his kayak service?

To determine if the father should enter the market, we need to compare the potential profit from offering kayak services with the cost of operating the kayak. The profit is calculated as the difference between the daily revenue and the cost of running the kayak. In this case, the exercise says that the cost of the father for each kayak trip is €2 per passenger plus a daily fixed cost of €5. So, the profit will be:

Profit = Revenue - Cost, where the revenue equals the price per ride in the kayak times the number of non-guest hotel, and the cost equals €2 per passenger plus a daily fixed cost of €5

Let's consider the following scenarios:

Scenario 1: Father sets a price lower than the hotel boat's fee (e.g., €15). In this case, we assume that all the non-guest hotel will choose to cross with the kayak as it is cheaper.

- Revenue = €15 × 16 people = €240
- Cost = Fixed Cost (€5) + Variable Cost (€2 x 16 people) = €37
- Profit = Revenue (€240) – cost (€37) = €203

Scenario 2: Father sets a price equal to or higher than the hotel boat's fee (e.g., €20 or higher). If the price of the kayak is the same as the price the hotel boat charges to non-guests, then lets assume that half the consumers will decide to cross with the Kayak “for a more adventurous experience”, and half will cross with the hotel boat “for a more comfortable ride”

- Revenue = €20 × 8 people = €160
- Cost = Fixed Cost (€5) + Variable Cost (€2 x 8 people) = €21
- Profit = Revenue (€160) – cost (€21) = €139

If the Kayak charges a higher price than the hotel boat (i.e. higher than €20) then we can assume that nobody will cross with the kayak, as the hotel boat is cheaper. In this case, the revenue for the kayak is 0 and the profits will be negative, i.e. Profit = Revenue (€0) – Cost (€5) = - €5

Considering the scenarios above, we can conclude that the maximum price the father can charge to attract customers away from the hotel boat is €20. Charging more than this would discourage customers from choosing the kayak service. The potential profit the father can earn depends on the number of non-hotel guests willing to choose his kayak service over the hotel boat.

This numerical exercise illustrates the decision-making process the father must undertake to determine if entering the market and challenging the hotel boat's monopoly is a profitable venture.

Consider now the possibility that the hotel boat can block the entry of the kayak into the market and to drive away competition. Following the example above, assume the hotel boat currently charges a fee of €20 for non-guests to cross from Noja to Isla during high tide. The cost to the hotel boat for each trip is €1 per passenger plus a daily fixed cost of €6. However, the hotel boat also carries hotel guests who even don’t pay directly for the trip they do pay for accommodation and part of these fees will be used to cover the boat transportation fee. Assume that for every accommodation fee €5 is used to pay for the hotel boat service.

Recall that the cost to the father for each kayak trip is €2 per passenger plus a daily fixed cost of €5. If the father decides to enter into this market, as we explained above, he will charge a riding fee of €20 or less, otherwise, the demand for the kayak will be €0. For this case study, let's assume that he enters the market and charges a riding fee of €20 (exactly the same price as the hotel boat).

Assume also that the average daily number of non-hotel guests who want to cross on a high tide is 16 people, and the average daily number of hotel guests who want to cross on a high tide is 18 people. However, all the hotel guests have to pay for the boat service (included in the accommodation fees) independently on whether they use the service[4].

[4] For simplicity, we will calculate the profit of the hotel boat just using the data of non-hotel guest. However, in reality, the profit should include the fees (part of the accommodation fees) which are used to cover the hotel boat service. Note that this will not change the results of this case study, which tries to illustrate in a simple way, the game theory principles of a new entrant into a market. In any case,

The father with the kayak has two possible strategies[5]: (1) enter the market and compete with the hotel boat; (2) not enter the market. If he doesn't enter the market then his profit will be 0, as there will not be any revenue but the cost of running the kayak. Then all the non-hotel guest will have to get a ride with the hotel boat, and so, in this case, the profit from the hotel boat will be as follows:

Revenue (hotel boat) = €20 x 16 non hotel guest = €320

Cost (hotel boat) = Fixed Cost (€6) + Variable Cost (€1 x 16 passengers) = €22

Profit (hotel boat) = Revenue (€320) – Cost (€22) = €298

Now, assume that the father with the kayak decides to enter into the market and charge a fee equal to the hotel boat fee, i.e. €20. In this case, the hotel boat has two possibilities, either accommodate the entry or fight to try to drive out the kayak from the market. If it decides to accommodate the entry then it will charge a fee of €20 and the demand will be divided between the hotel boat and the kayak, so:

Revenue (hotel boat) = €20 x 8 non hotel guests = €160

Revenue (kayak) = €20 x 8 non hotel guests = €160

Cost (hotel boat) = Fixed Cost (€6) + Variable Cost (€1 x 8 passengers) = €14

Cost (kayak) = Fixed Cost (€5) + Variable Cost (€2 x 8 people) = €21

Profit (hotel boat) = Revenue (€160) – Cost (€14) = €146

Profit (kayak) = Revenue (€160) – Cost (€21) = €139

---

the hotel guests' fees will increase the revenue and so the profit of the hotel boat, but the principles of the exercise remain the same.

[5] In game theory, a strategy refers to a well-defined plan or a set of choices made by a player in a game to achieve their objectives. It outlines how a player will act or respond to different possible situations or moves by other players. Strategies in game theory are essential for making rational decisions, and they take into account the player's goals, preferences, and anticipation of how other players might behave. A player's strategy is a key determinant of the outcome of the game and influences the player's payoffs or outcomes.

If the hotel boat decides to fight the entrance of the kayak in the market, then they will try to set a price below the price which the kayak will offer, to try to drive out the kayak out of the market. See that the kayak has a total cost of €2 per passenger plus a daily fixed cost of €5. This means that its marginal cost, is €2 - Marginal cost is the additional cost incurred by producing one more unit of a good or service. It represents the change in total cost when the quantity of output is increased by one unit. Marginal cost is an important concept in economics and business decision-making because it helps determine the optimal level of production and pricing for a firm. In general, firms aim to produce at a quantity where marginal cost equals marginal revenue to maximize their profit. So, if there was a price war[6], then the kayak would be unable to set a price below €2, otherwise, it would incur losses in the long run[7] and go out of business. However, the hotel boat’s total costs are €1 per passenger plus a daily fixed cost of €6, this means that its marginal cost is €1 and it could charge as low as €1 per passenger before incurring in losses. Assume, that the hotel boat charges a price just below €2 to drive the kayak out of the market, specifically assume is charges a price €1.9 for every non-hotel guest. The kayak will have to charge also €1.9 if he wants to get any demand:

Revenue (hotel boat) = €1.9 x 8 non hotel guests = €15.2

Revenue (kayak) = €1.9 x 8 non hotel guests = €15.2

Cost (hotel boat) = Fixed Cost (€6) + Variable Cost (€1 x 8 passengers) = €14

Cost (kayak) = Fixed Cost (€5) + Variable Cost (€2 x 8 people) = €21

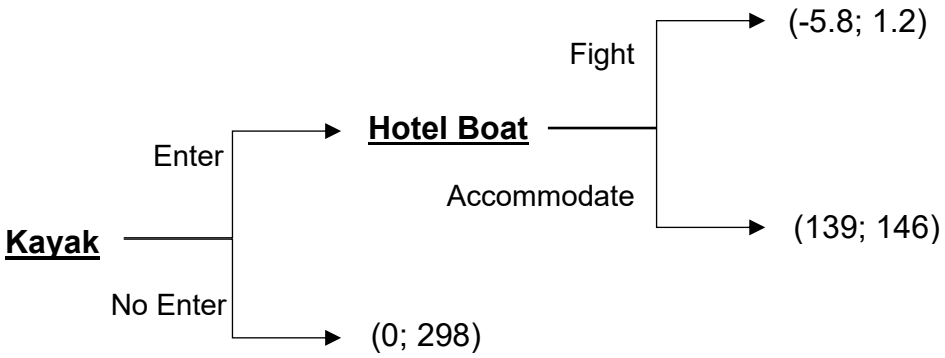
[6] A price war in competition is a situation where competing businesses, typically in the same industry, engage in a series of price reductions and aggressive price cuts to gain a larger share of the market or to undermine their competitors. Price wars can lead to lower prices for consumers but can also harm profitability for the businesses involved. They often result from intense rivalry and a focus on price as a competitive strategy rather than product differentiation or other factors. Price wars can be short-lived or prolonged, depending on the strategies and resources of the companies involved.
[7] The short run in economics refers to a time period during which at least one factor of production is fixed, limiting a firm's ability to adjust its operations. It is a period when some costs are considered fixed, and firms can make only limited adjustments to their production and resources. The long run in economics represents a time frame in which all factors of production are variable, allowing firms to make fundamental adjustments to their operations, including changes in facilities, equipment, and workforce. In the long run, there are no fixed costs, and firms have greater flexibility to adapt to changing market conditions.

Profit (hotel boat) = Revenue (€15.2) – Cost (€14) = €1.2

Profit (kayak) = Revenue (€15.2) – Cost (€21) = - €5.8

We can represent this using a sequential game (Figure 1), we use this representation to analyse and understand the strategic interactions and decision-making process of the game above. The representation involves specifying the players (hotel boat and kayak), their strategies (for the kayak: enter or not enter in the market; for the hotel boat: fight or accommodate if the kayak decides to enter), the order of moves, and the possible outcomes of the payoffs (in parenthesis) we calculated above.

Figure 1: The Sequential Game




Note: in the parenthesis, the first payoff corresponds to the kayak's profit and the second one to the hotel boat's profit. Both, the kayak and the hotel boat, are profit maximiser, i.e. both seek to produce the service in a way that generates the highest level of profit.

We can see that if the ultimately the decision of whether to enter the market is the kayak's decision, but this decision will depend on the hotel boat strategy. If the Kayak enter the market the hotel boat will have the option of either to fight or to accommodate. As it is a profit maximiser, and assuming the game its just played one time[8], the hotel boat will decide to accommodate. The kayak now know that the hotel boat will accommodate if it enters the market and so its profit will be €139 compared to €0 if it doesn't enter the market, as it is a profit maximiser the kayak will

[8] For simplicity, it doesn't exists the possibility that it fights now and then returns to monopoly profits once the kayak is out of the market is a subsequent period.

enter the market. The equilibrium in this game will be to enter the market for the kayak and accommodate for the hotel boat.

In this sequential game theory exercise, we witness how real-world business decisions can be analysed using game theory principles. The father must evaluate the potential benefits of entering the market against the challenges of competing with an established monopoly. The woman's input and gesture offer additional elements to consider. As the story unfolds, the outcome of this game depends on the strategic choices made by each player, ultimately shaping the future of kayaking transportation in the area.

Update. The father entered the market for a day and realised he could not spend any time with his family on holiday. Assuming this is something he likes to do, this is an opportunity cost, and may affect his decision to enter which we leave for a discussion another day.