Hazards of Price Competition
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What happens if a small number of firms compete on price: that is, they produce identical products and try to attract business by pricing below the competition? In some situations, the result can be that price is driven down to marginal cost and no one makes any money. This is particularly painful in industries with high fixed costs: marginal cost is well below average cost and firms pricing at marginal cost lose money. A good example is airlines, where price competition in the 1990s resulted in pretty much everyone but Southwest losing money.

The point of this session is that the price-cutting game is a prisoner’s dilemma: it’s a bad outcome, but the outcome is inherent in the game. The outcome is sometime referred to as the Bertrand trap, named after the 19th-century French economist Joseph Bertrand. The lesson to you should be: price competition is hazardous. Or as they say in the business world: avoid “commodity” businesses.

The Price-Cutting Game

Consider an industry with two firms producing a single homogeneous product. Suppose each has the same cost structure. We’ll show that each has an incentive to reduce its price below the other’s as long as price is above marginal cost. The result: progressive price-cutting reduces the price to marginal cost.

Let’s look at this a little more formally. Suppose marginal cost is a constant c and demand for the product is D(p). If one firm has a lower price than the other, it gets the whole market, D(p). If they charge the same price, they each get half the market, D(p)/2. (This is arbitrary, but since it’s not an essential part of the story we thought it best to keep it simple.)

Now let’s look at the incentive to cut price. If each is charging the same price, then they split the market. If the price is above marginal cost, they both make a profit. But what if one charges a (slightly) lower price? Its profit per unit falls (a little, since the price cut was small), but because it gets the whole market its profits go up. (For a small enough price reduction, profit should almost double.) Therefore it has a clear incentive to reduce price. The picture changes only when price falls to marginal cost. At this point, further reductions in price are unprofitable. We illustrate this graphically in Exhibit 1, where for each firm we graph the optimal price for one firm given the price charged by the other. We call the lines showing these optimal choices “reaction curves.” They’re analogous to best responses in matrix games. In fact, the only difference is that price is a continuous
variable, not discrete, so it’s easier to describe strategy graphically rather than in a table or matrix.

The optimal strategy for each firm, then, is to reduce price below the other, unless price equals marginal cost. Since each firm is trying to undercut the other, we end up with price equal to marginal cost. In game theory terms, this is a Nash equilibrium, the intersection of the reaction curves of the two firms (Exhibit 1). In economic terms, we have reproduced the competitive solution (price equal to marginal cost) with only two firms. It’s a remarkable result and an important business lesson: you can have intense competition even with a small number of firms.

Here’s another attack on the same problem, this time using our familiar matrix structure. The goal is to show that price-cutting is a prisoner’s dilemma and bring up some details that we skipped earlier (probably for good reason!). Suppose marginal cost is constant at c and demand is

\[ Q = D(p) = a - bp. \]

You might recall that the monopoly price for this problem is \( p = \frac{a+bc}{2b} \). The best the two firms can do together is charge the monopoly price and split the market. (That’s illegal if they do it explicitly, but keep it in mind as a point of comparison.)

Suppose both firms charge the same price \( p \), which is well above marginal cost. What are the costs and benefits of charging a lower price, \( p-\varepsilon \) (the idea is that \( \varepsilon \) is a small positive number, not to be confused with the elasticity). The payoff matrix for the two prices, \( p \) and \( p-\varepsilon \), is

\[
\begin{array}{c|cc}
& p & p-\varepsilon \\
\hline
p & A & B \\
p & A & 0 \\
p-\varepsilon & B & C \\
\end{array}
\]

We’ll show that \( B > A > C \) as long as the price is below the monopoly price and above marginal cost. Since \( B > A \), the lower price is a dominant strategy and both firms will cut price. And since \( A > C \), this is a prisoner’s dilemma, a “lose-lose” game in which the incentives leave both firms worse off.

Now let’s fill in the details. (This isn’t required: skip if you think the explanation so far is enough). When both firms charge \( p \), economic profits are

\[ A = (p-c)(a-bp)/2. \]
If one charges $p$ and the other $p-\varepsilon$, the firm charging $p$ sells nothing and its economic profits are zero. The firm charging the lower price gets the whole market and earns profits of

$$B = (p-\varepsilon-c)(a-bp+b\varepsilon) = 2A + (a+bc-2pb)\varepsilon - b\varepsilon^2.$$  

If we choose $\varepsilon$ small enough, $B$ is not only larger than $A$, it’s almost twice as large. Hence price-cutting is a dominant strategy.

How about $A > C$? If this holds, then firms have made themselves worse off by cutting prices. You might guess this is true: the farther away you get from the monopoly price, the less you make. Algebraically,

$$C = (p-\varepsilon-c)(a-bp+b\varepsilon)/2 = B/2 + (a+bc-2pb)\varepsilon/2 - b\varepsilon^2/2,$$

which is less than $A$ if $p < (a+bc)/2b$ (the monopoly price). (This last step is a little tedious, but you get the idea.)

Quick summary. We’ve shown two things: (i) A firm has a clear incentives to undercut the price of its rival. (ii) The result of such price-cutting is that both firms price at marginal cost and make no money. Does this mean they played the game badly? No! It’s simply not a very good game to be playing. The best thing a firm can do in this situation is to try to play a different game.

**Escaping the Trap**

We’ll spend several sessions exploring ways to escape the “Bertrand trap” of competitive price-cutting, but it’s worth a quick look now. Here’s a partial list:

- **Buy your competitor.** This has clear anti-trust problems, but you can see the incentive for firms. Alternatively, one firm might decide to exit (since it’s not making any money) leaving the other with a monopoly.

- **Collude on price.** Also illegal. But what if you and your competitor simply come to understand that price competition hurts you both? Are there legal ways of interacting that avoid the problems of price competition? More on this soon.

- **Build a cost advantage.** Suppose you (as Firm 1) have a cost advantage over your competitor (Firm 2). Then the game plays out like this: you reduce your price to just below your competitor’s cost. At that point Firm 2 drops out and you get the whole market. Your profit is determined by the difference in your costs. See Exhibit 2. This is yet another example of the value of low cost.
• Differentiate your product. Generally, products are not homogeneous: buyers perceive differences between them that moderate the tendency for the low price to take the whole market. In such cases, the pressures of price competition are less severe, but they are generally there. We’ll talk more about product positioning later.

Numerical Example: A Quantity Game (Optional)

We can use the same tools to examine a game in which firms choose quantity instead of price. It illustrates the benefits of firms limiting capacity: if your capacity is limited, so is your ability to capture market share through price-cutting.

Suppose two firms produce a product at the same marginal cost c and face demand

\[ Q = q_1 + q_2 = a - bp. \]

With this setup, you’ll recall that the monopoly price is \( p_m = (a+bc)/2b \) and the quantity sold is \( Q_m = (a-bc)/2 \). The competitive solution is to set price equal to marginal cost, \( p=c \), which results in quantity \( Q_c = a-bc \) (double the output in this case). The best the two firms can do is to produce – together – the monopoly output and share the profit. The question is whether this is a sustainable outcome – whether the temptation to undercut your rival will make this impossible to carry out.

One approach to this problem is to consider the firms playing a game in which each chooses its own quantity to maximize its profit, given the output choice of the other. You might recognize this as the Nash equilibrium in q quantity game. We refer to this as Cournot competition, after another 19th-century French economist, Augustin Cournot.

Intuitive approach. Consider the choices of Firm 1. If Firm 2 produces zero, then Firm 1 is effectively a monopolist and the best it can do is produce the monopoly level of output. Similarly, if Firm 2 is producing the competitive level of output, then the best Firm 1 can do is produce zero, since any additional output would drive price below marginal cost. If you take these two points and connect them you get Firm 1’s reaction curve, as in Exhibit 3. Doing the same analysis for Firm 2, you get its reaction curve, also pictured in Exhibit 3. The Nash equilibrium is where the two curves cross. You can tell from the graph that the output levels for this game are below the competitive level but above the monopoly level.

Mathematical approach. Start by expressing each firm’s profit (payoff) in terms of the outputs (strategies) of the two firms:

\[
\text{Profit}_1(q_1,q_2) = (p-c)q_1 = q_1(a-q_1-q_2-bc)/b \\
\text{Profit}_2(q_1,q_2) = (p-c)q_2 = q_2(a-q_1-q_2-bc)/b.
\]
(Take a minute to work this out for yourself.) Now let each firm choose its quantity given the other’s choice. Firm 1 maximizes its profit by differentiating its profit with respect to its own quantity:

$$\frac{\partial \text{Profit}_1(q_1, q_2)}{\partial q_1} = \frac{(a-2q_1-q_2-bc)}{b} = 0,$$

which implies the reaction curve (ie, solve this for $q_1$),

$$q_1 = \frac{(a-bc)}{2} - \frac{q_2}{2}.$$

Similarly, the reaction curve for Firm 2 is $q_2 = \frac{(a-bc)}{2} - \frac{q_1}{2}$. The Nash equilibrium is the solution of these two equations: $q_1 = q_2 = \frac{(a-bc)}{3}$. Total output is $Q = q_1 + q_2 = 2\frac{(a-bc)}{3}$, which you can show is between the competitive and monopoly values.

Bottom line: The capacity game isn’t as extreme as the price game. Output and price are between the competitive and monopoly values. In industries where there is a clear capacity constraint (it’s not easy to scale up production), this provides a formal justification for limiting your capacity.

Frequently asked question: Given capacity, why don’t firms engage in price-cutting? If the capacity isn’t there, you can’t cut price.

**Other Examples**

Airlines. Some observers think that airlines increased capacity too much in the 1990s, buying new planes and expanding into new markets. With fewer planes, they would have less ability to expand output and drive the price down.

Long distance telephony. In hindsight, too much capacity was added in the late 1990s, which resulted (this is a high-fixed-cost, low-marginal-cost business) in sharp price drops. AT&T is one of the casualties.

Manufacturing. A few years ago, a senior exec from a New Jersey-based company spoke at the annual meeting of the Asian Business Society. At the time, many firms were discussing the possibility of buying Asian companies in or near bankruptcy. In his view, excess capacity in his industry had led to overly aggressive price-cutting. He mentioned trying to buy three Asian manufacturing facilities, with the idea of using one and closing the other two to reduce capacity in the industry.

*Written by Chris Chamberlain under the supervision of Luis Cabral and David Backus. © 2001 Luis Cabral and David Backus.*
Exhibit 1
Reaction Curves in Price Game

Comment: Each firm undercut the other’s price, until price hits its marginal cost.

Exhibit 2
Reaction Curves in Price Game When Firm 1 Has Lower Cost

Comment: This time, the low cost firm reduces price to just below the other’s cost, which is enough to drive it out of the market.
Exhibit 3
Reaction Curves in the Cournot Capacity Game

Comment: In this game, firms choose quantities between the monopoly output ($Q_m$) and the competitive output ($Q_c$).