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15.013 – Industrial Economics for Strategic Decisions

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Lecture Notes on Entry and Reaction to Entry

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In these notes we will examine some issues that can arise when a firm tries to enter a market. We will begin by considering some of the ways that uncertainty over future market conditions can affect an entry decision that involves a large sunk cost investment. As we will see, uncertainty creates an *opportunity cost* of investing now rather than waiting for new information. (In effect, the first section of these notes provides a very brief introduction to the theory of "real options.")

Next, we will focus on entry into a market that has been dominated by a monopolist or a near-monopolist. First, we will consider the question of whether it might be advantageous to enter on a small scale. Might such entry lead the incumbent firm to respond in an accommodating way, so that the new entrant can survive and earn profits? Second, we will consider the problem of entry in a market for an "experience" good. We will see how an incumbent firm in such a market can have an important first-mover advantage that can make entry by another firm difficult or impossible. We will also see how this first-mover advantage can help explain the success of Gillette with its Sensor and Mach 3 razors.

1 Entry Under Uncertainty

Often, entry into a market involves a large sunk cost, combined with uncertainty over future market conditions, and thus the eventual return on the investment. Sometimes by waiting the firm can learn more about market conditions and the amount of revenues it can expect to earn. This information can come from the market itself (for example, a firm deciding whether and when to develop a large oil reserve can simply observe the evolution of oil prices), or the information can come from observing the success or failure of other firms in the market. In either case, we can think of the entry (and investment) decision as analogous to the exercising of an option. We refer to such investments as "real options," and we use option valuation techniques developed in finance to determine when such investments should or should not be made.

The idea of a "real option" is fairly straightforward: A firm has an *option* to invest. It can exercise this option now, in the future, or never. The exercise price of the option is the cost of the investment. If the firm exercises its option and invests, it receives an asset, which could be a factory (or apartment building, or developed oil reserve, or patent, etc., etc.). The value of that asset will fluctuate unpredictably over time, just as the price of a stock fluctuates over time. Like many stocks, the asset yields a "dividend," which could be the net cash flows from the factory, net rental income from the apartment building, etc. Thus the decision to invest is much the same as the decision to exercise a call option on a dividend paying stock.

To explore this further, consider the decision to build a widget factory that will produce one widget per year forever. The price of a widget now is \$100, but next year it will go up or down by 50% (with equal probability), and then it will stay at its new higher or lower level:

$$\begin{array}{ccccccc}
\underline{t=0} & & \underline{t=1} & & \underline{t=2} & & \cdots \\
 & & P_1 = \$150 & \rightarrow & P_2 = \$150 & \rightarrow & \\
 & \frac{1}{2}\nearrow & & & & & \\
P_0 = \$100 & & & & & & \\
 & \frac{1}{2}\searrow & & & & & \\
 & & P_1 = \$50 & \rightarrow & P_2 = \$50 & \rightarrow &
\end{array}$$

The cost of the factory is \$800, and it only takes a week to build. We'll assume that the correct discount rate is 10 percent. Is this a good investment? Should we invest now, or wait one year and see whether the price of widgets goes up or down?

Suppose we invest now. Then the NPV of the investment is

$$\text{NPV} = -800 + \sum_{t=0}^{\infty} \frac{100}{(1.1)^t} = -800 + 1,100 = \$300$$

This is much greater than zero, so the simple NPV rule that you learned in your introductory finance course would tell you to go ahead and invest. But suppose that instead of investing now we wait a year. In that case we would only invest if the price of widgets goes up to \$150. (If the price drops to \$50 investing would then have a negative NPV.) Thus the NPV *as of today* if we wait a year is:

$$\text{NPV} = (.5)\left[-\frac{800}{1.1} + \sum_{t=1}^{\infty} \frac{150}{(1.1)^t}\right] = \frac{425}{1.1} = \$386$$

Clearly waiting is better than investing now. The value of being able to wait — i.e., the value of having the flexibility of being able to invest either now or later — is the difference in the NPVs: \$386 - \$300 = \$86.

What's wrong with the simple NPV rule that tells us to invest as long as the NPV of a project is greater than zero? After all, building the factory today still has a positive NPV. The problem is that when we calculated the NPV of investing today we ignored an important *opportunity cost*, namely the cost of "killing" our option to wait for more information. In Chapter 2 of Dixit and Pindyck, *Investment Under Uncertainty*, this simple investment problem is solved in a more circuitous but informative way — by using standard option pricing techiques. There we show that the *option to invest* is worth \$386, which is precisely the NPV that we just found for the optimal investment strategy of waiting a year before deciding whether to invest.

Another way to value flexibility is to ask how high an investment cost I would we accept to have a flexible investment opportunity rather than a "now or never" one? To answer this question, we find the investment cost $\overline{I}$ that makes the NPV of the project when we wait equal to the NPV when $I = \$800$ and we invest now, i.e., equal to \$300. Substituting $\overline{I}$ for the 800 and \$300 for the \$386 in equation for NPV above:

$$\text{NPV} = (.5)\left[\frac{-\overline{I}}{1.1} + \sum_{t=1}^{\infty} \frac{150}{(1.1)^t}\right] = \$300$$

Solving for $\overline{I}$ yields $\overline{I} = \$990$. Thus an opportunity to the build factory now *and only now* at a cost of \$800 has same value as an opportunity to build the factory now *or next year* at a cost of \$990.

Why use option-theoretic methods, which are generally more complicated than the simple NPV rule, to evaluate investment decisions? Here are a few reasons:

- With uncertainty and irreversibility, the NPV rule is often wrong — *very* wrong. Option theory gives better answers.
- We can value important "real options," such as value of land, offshore oil reserves, or a patent that provides an option to invest.
- We can determine the *value of flexibility*. For example, the flexibility from delaying electric power plant construction, or the flexibility from installing small turbine units instead of building a large coal-fired plant.
- Option theory emphasizes uncertainty and treats it correctly. (The use of the NPV rule often doesn't.) This in turn helps us to focus attention on the nature of uncertainty and its implications.
    - Managers often ask: "What will happen (to oil prices, to electricity demand, to interest rates,...)?" Usually, this is the wrong question. The right question is: "What *could* happen (to oil prices, to...), and what would it imply?"
    - Managers often underestimate or ignore the extent of uncertainty and its implications.

This is not a course in real options. However, you should be aware of the optionality involved in many of the strategic economic decisions facing a firm. We will revisit this issue from time to time throughout this course.

2 Entry on a Small Scale

Suppose you are considering entering a market currently dominated by a monopolist.[1] Should you enter, and if you do, how will the monopolist respond? Might it be advantageous to enter in a very limited way (by installing only a small amount of production capacity) in the hope that the incumbent firm will then be more accommodating and not undercut your prices? As we will see, the reaction that we can expect to entry, and hence the desirability of entry itself, can depend crucially on the scale of entry.

Suppose a monopolist is currently selling in a market with demand curve $Q = 100 - P$. Hence the monopolist's marginal revenue function is given by $\text{MR} = 100 - 2Q$. The monopolist has a constant marginal cost of \$20 per unit. By setting marginal revenue equal to marginal cost, you can check that the monopolist's profit-maximizing price and quantity are \$60 and 40 units, respectively, and its profit is $\pi_m = 40(60 - 20) = \$1600$.

Now suppose that you are considering entering this market. You have less experience than the monopolist, so your marginal cost is higher—\$30 per unit instead of \$20. Suppose you enter with enough production capacity to serve the entire market. What can you expect to happen?

We will assume that both you and the monopolist produce an identical product, so that if your prices are equal, consumers will, out of convenience, continue to buy from the monopolist. However, consumers will shift all of their sales if one firm has an even slightly lower price. In this case, you can only expect to make money by setting your price below the \$60 price that the monopolist had been charging earlier. But the incumbent must then match your price, or else it will lose everything. You can continue to lower your price all the way down to your marginal cost of \$30, but the incumbent will still undercut you. Even if you charge \$30 (and thus make no money), the incumbent will match you, getting all of the customers, and still making \$10 per unit. Thus you can feel certain that the incumbent will respond aggressively to your entry, and you will not make money. It looks as though entry

[1] This discussion is based on J. Gelman and S. Salop, "Judo Economics: Capacity Limitation and Coupon Competition," *Bell Journal of Economics*, 1983.

is not a good idea.

But now let's try a different strategy. Suppose you enter the market with only a *limited amount of capacity*, e.g., a capacity of 10 units. (You build a plant that is only capable of producing 10 units per period.) The incumbent knows that you can sell no more than this. What will happen now?

The entrant will have to undercut the former monopolist's price in order to sell anything. Suppose the entrant does this, charging a price P_E which is less — but only *slightly* less — than the incumbent's price P_I. Consumers will all prefer to buy from the entrant, but the entrant does not have enough capacity to sell to everyone. We will assume that the entrant's output is "rationed" randomly among all consumers willing to pay. For example, if the total demand for the entrant's output is 70 units, each consumer has a $10/70 = 1/7$ chance of purchasing from the entrant.

In this case, what is the *residual demand facing the incumbent* when the entrant undercuts ($P_E < P_I$)? Note that demand for the entrant's output will be $Q_E^D = 100 - P_E$, since with $P_E < P_I$ everyone would prefer to buy from the entrant. The entrant, however, can supply only 10 units. Assuming that these 10 units are rationed randomly, each consumer will have a $10/(100 - P_E)$ chance of being able to buy from the entrant. Thus the residual demand facing the incumbent is:

$$Q_I = \left[1 - \frac{10}{100 - P_E}\right](100 - P_I) = \left(\frac{90 - P_E}{100 - P_E}\right)(100 - P_I)$$

Hence the incumbent's demand (average revenue curve) is given by:

$$P_I = 100 - \left(\frac{100 - P_E}{90 - P_E}\right) Q_I$$

and its marginal revenue curve is given by:

$$\text{MR}_I = 100 - 2\left(\frac{100 - P_E}{90 - P_E}\right) Q_I$$

Setting marginal revenue equal to the incumbent's marginal cost of \$20, we find that the incumbent's optimal quantity is now:

$$Q_I^* = 40\left(\frac{90 - P_E}{100 - P_E}\right)$$

and its optimal price is once again \$60.

Note that the incumbent no longer has an incentive to drop its price and thus undercut the entrant. The incumbent makes more money by maintaining its original monopoly price and accommodating the entrant, letting it sell its 10 units.

We have not specified what price the entrant should charge, but that is easy to determine. The entrant does best by just slightly undercutting the incumbent, e.g., charging a price of \$59. Then the entrant sells approximately 10 units (its capacity) and the incumbent sells 30 units. The incumbent therefore makes a profit of $(60-20)\times 30 = \$1200$. The entrant earns a profit of nearly \$300.

The incumbent is now earning a smaller profit (\$1200 vs. the \$1600 it earned as a monopolist), so why not just undercut the entrant and drive him out of the market? To do so would mean charging a price of \$30. The incumbent's profits would then be $(30-20)\times 70 = \$700$. The incumbent is better off accommodating the entrant.

We have seen that an entrant that comes in on a small scale can rationally expect accommodating behavior from the incumbent firm. This is a rationale for the pattern of start-ups in the U.S. airline industry that we witnessed during the past twenty years. Small start-up airlines like Kiwi International and Reno Air have come in with just two or three leased planes, offering only a limited number of flights on several point-to-point routes. In the case of Kiwi (flying originally out of Newark and then later out of Boston), the reaction was indeed one of accommodation. (Kiwi nonetheless went bankrupt.) That was not the case, however, with Reno Air—Northwest Airlines attacked aggressively on its overlap routes.

3 Markets for Experience Goods

Now let us turn to a market for an "experience" good. (An example would be a market for razor blades, underarm deodorant, or disposable diapers.) An experience good has the following characteristics:

- First, an individual consumer can be expected to use at most one brand at any instant of time. Thus, we will assume that the consumer might use either a Gillette razor or a Schick razor, but not both.

- Second, any particular brand either "works" or "doesn't work" for a particular consumer. In other words, either the brand "does the job" as the consumer expects, or it doesn't.

- Third, the only way that a consumer can resolve the uncertainty over whether the brand will work or won't work is by purchasing it and trying it. The fact that a particular razor or deodorant "works" for your friend does not necessarily mean that it will "work" for you.

Note that with an experience good, the consumer gets no value from variety. Unlike breakfast cereals and other food items, there is no benefit from using one brand of deodorant or razor on Mondays, Wednesdays, and Fridays, and another brand on the other days. All that matters is whether the particular deodorant or razor does the job it is supposed to do.

3.1 Entry in the Market for an Experience Good.

Suppose that such a market is currently served by a monopolist.[2] It might have taken some time for this monopolist's product to diffuse through and eventually saturate the market. In any case, we will assume that enough time has gone by so that consumers have learned that the product "works" and will buy the product as long as the value to them is at least as great as the price that the monopolist charges. We will now consider what will happen if a second firm should try to enter this market with a similar product.

Suppose that the incumbent firm (the former monopolist) is charging a price P_I. To keep things simple, we will assume that the incumbent maintains this price after entry occurs, and that the entrant expects the incumbent to do this. (Of course, if the incumbent were to lower its price after entry occured, that would make success by the entrant even more unlikely.) The entrant must now consider how many consumers currently using the incumbent's brand are likely to switch to his brand.

[2] The model described here is based on R. Schmalensee, "Product Differentiation Advantages of Pioneering Brands," *AmericanEconomicReview*, June 1982.

Consider a consumer currently using the incumbent's brand. Suppose that consumer has a value v for the good and thus enjoys a consumer surplus of $v - P_I$. (See Figure 1.) Suppose the entrant charges a price P_E, and that this consumer (along with all other consumers) thinks that the probability that the entrant's brand will "work" is $(1 - \pi)$, so that the probability that it will *not* work is π. In this case, the consumer will try switching to the entrant's brand if the following condition holds:

$$\pi \left[-P_E + \frac{v - P_I}{r} \right] \; + \; (1 - \pi) \left[\frac{(v - P_E)(1 + r)}{r} \right] \; \geq \; \frac{(v - P_I)(1 + r)}{r}$$

Here, the first term in brackets on the left side of the equation is the loss to the consumer if the entrant's brand does not "work." That loss is the money spent (P_E), plus the present value of the surplus enjoyed from switching back to the incumbent's brand in the next period. The second bracketed quantity in this equation is the present value of the flow of surplus to this consumer that results if the entrant's brand "works." Weighting by the appropriate probabilities gives the expected value of trying the entrant's brand; that must be at least as great as the present value of simply sticking with the incumbent's brand. With a little algebra, this equation can be rewritten as follows:

$$P_E \; \leq \; P_I \; - \; \frac{r\pi v}{1 + r - \pi}$$

Note that if $\pi = 0$ (so that consumers are certain that the new brand will "work" just as the first brand did), then all the entrant needs to do to get consumers to switch is to price just under the incumbent's price. However, things become much more difficult for the entrant if consumers are not sure whether the new brand will "work." For example, suppose that $\pi = .50$, and the interest rate r is equal to 10 percent. Then the consumer will try the new brand only if:

$$P_E \; \leq \; P_I - 0.83v$$

In Figure 1, this is shown as the dashed line AB. In other words, consumer currently buying the incumbent's brand will switch only if the entrant's price is below this dashed line. Observe that the higher the consumer's valuation (i.e., the farther to the left we are along the demand curve), the lower the entrant's price must be to get the consumer to

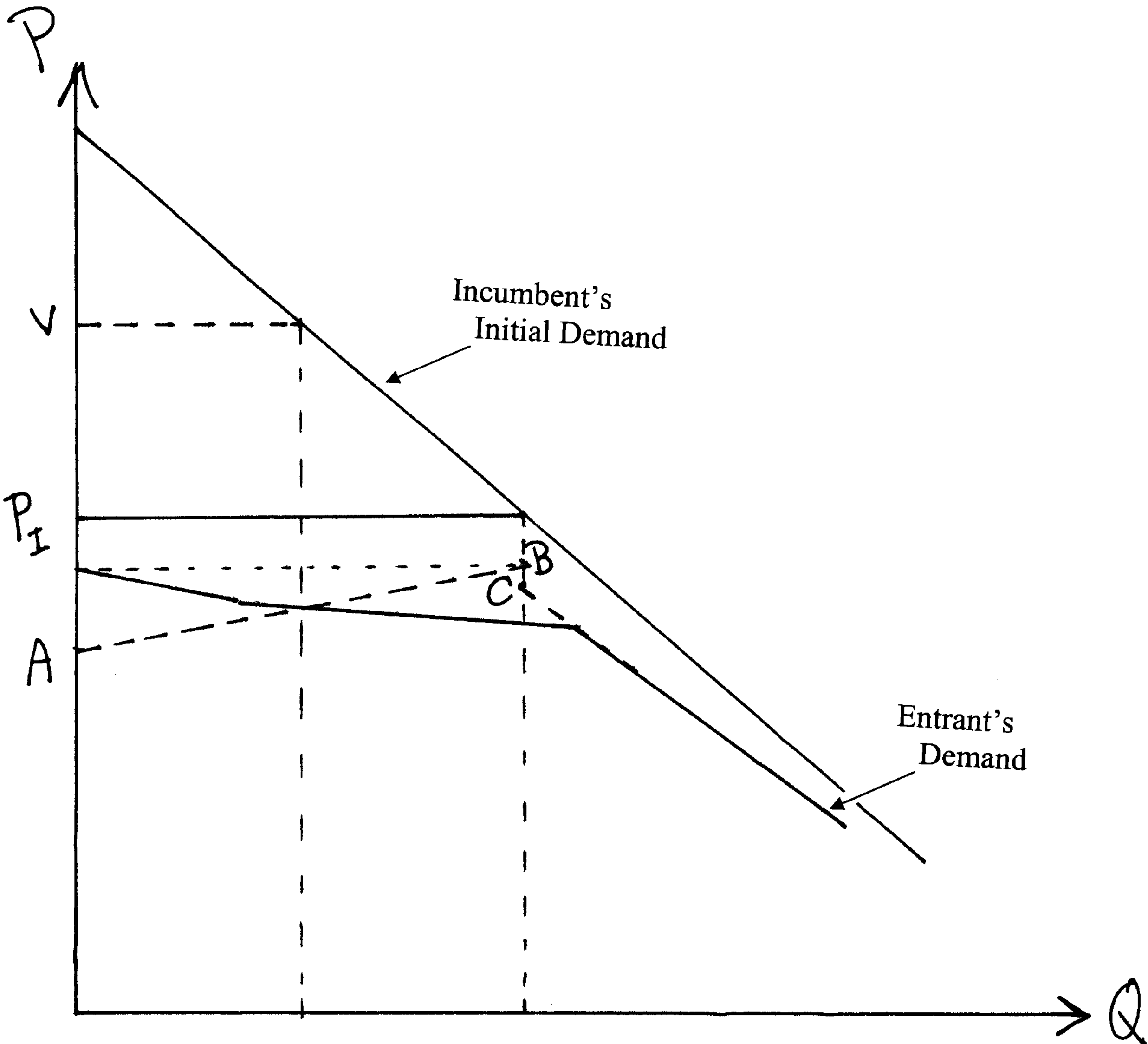

Figure 1: Entry in a Market for an Experience Good

try its brand. The reason is that consumers with very high valuations have more to lose by trying the entrant's brand; part of what they lose if the entrant's brand does not work is the consumer surplus that they would have enjoyed in the first period from use of the incumbent's brand.

Of course, those consumers who have low valuation for the good will not be using the incumbent's brand, and they are also candidates for the entrant's brand. If the entrant's price is below the incumbent's price, and if they believe that the probability that *each* brand will not work is π, then they will try the entrant's brand as long as:

$$-\pi P_E + (1-\pi)\left[\frac{(v-P_E)(1+r)}{r}\right] \;\geq\; 0$$

This, in turn, can be rewritten as:

$$P_E \;\leq\; \frac{(1+r)(1-\pi)}{(1+r-\pi)}v$$

Continuing with our example, if $\pi = .5$ and $r = .1$, then the condition becomes that $P_E \leq .9v$. This condition is shown as a dashed line extending to the right from point C in Figure 1.

Figure 1 also shows the demand curve facing the entrant. The entrant must always price below the incumbent, but initially can expect to attract some consumers who currently are not using the incumbent's brand. However, the entrant's price must fall considerably before he can expect to begin picking up consumers who currently use the incumbent's brand.

It should be clear from this that uncertainty in the minds of consumers over whether a product will "work" for them gives an incumbent firm a considerable advantage. Likewise, it creates a considerable incentive for a firm to be the "first mover." The advantage occurs because consumers already using the incumbent's brand have little to gain by switching to the entrant's brand. The only thing they can gain is the lower price, but that must be weighed against the possibility that the entrant's brand won't "work."

For many experience goods the obstacles to getting a consumer to switch are even greater than what has been portrayed here. Consider deodorants and disposable diapers. What happens when such a product "doesn't work"? It is not just that the consumer will not enjoy the benefit of the product; in addition, the consumer might have to bear the cost of an allergic reaction to the deodorant, or several sleepless nights taking care of a baby that has developed diaper rash.

4 The Market for Razors

Gillette's success with razors and razor blades illustrates the importance of first mover advantage in experience goods. During the 1980s, Gillette had about 60% of the U.S. market for razors, Schick had about 20%, and Bic, Wilkinson and others accounted for the remaining 20%. These shares were stable, and – as we would expect with an experience good – there was very little brand switching by consumers.

In 1989, Gillette introduced its new Sensor razor, and it did so in a very aggressive way. It built two plants simultaneously (in Boston and Berlin), with plans to produce at full capacity immediately. It also launched a $100 milliion advertising blitz, which was unprecedented for a product of this kind. Gillette knew that the Sensor would cannibalize sales of its old Trac II razor, but it planned to sell the Sensor at a high price, and it also thought it could take market share from its competitors.

The Sensor was an immediate and enormous success. But why? Why didn't consumers stick with the razors (whether Schick's or the Gillette Trac II) that they were already using, and that "worked" for them? Does the success of the Sensor imply that the first mover advantage associated with experience goods is not as important as our analysis suggests? What do you think?

In the late 1990's, Gillette and Schick were again racing to introduce a new razor. Both companies introduced their new razors in early 1998. Both companies knew that Gillette gained an enormous advantage from its pioneering introduction of the Sensor, and both companies knew that a similar advantage would likely go to the company that was first to gain a significant share of the market for the next generation of razor. Gillette introduced its new razor – the Mach 3 – in July 1998, and Schick followed with its new razor a few months later. Once again, Gillette embarked on a $100 million advertising campaign. Like the Sensor, the Mach 3 was a great success. (In 2004, Gillette's market share exceeded 70%.)

If three blades is better than two, think how much better still five blades must be. That's how many blades Gillette's new Fusion razor has. Gillette has been hoping that five blades is at least better than the four blades on Shick's Quattro razor, which was introduced in 2003. But not surprisingly, some market analysts were skeptical. As one Business Week article suggested, "They have pushed the model to its limit."

The attached articles describe the Mach 3 and its introduction, as well as Gillette's more recent experience with the Fusion razor.